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# Marine Fisheries REVIEW

On the cover:
A spring chinook gillnetter on the Columbia River at Astoria, Oreg.


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# Areal Distribution of Marked Columbia River Basin Spring Chinook Salmon Recovered in Fisheries and at Parent Hatcheries

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*ABSTRACT—In 1971-73 approximately 4.1 million juvenile anadromous spring chinook salmon,* Oncorhynchus tshawytscha, *of the 1970 and 1971 broods of 21 Columbia River Basin hatchery facilties were marked and released. Sampling for marked fish was conducted in 1972-77 in all major marine fisheries from Monterey, Calif., north along the Pacific coast of North America to Pelican, Alaska; in main-stem Columbia River fisheries; and at parent hatcheries. A total of 23,290 marked fish were recovered: 15,331 in marine fisheries, 2,400 in main-stem Columbia River fisheries, and 5,559 in parent hatcheries. In the aggregate, 93 percent of the fish recovered in marine fisheries were recovered north of the mouth of the Columbia River. However, the percentage of marked fish recovered in marine fisheries south of the Columbia River varied widely among hatchery areas: in the case of the Snake River hatchery area, for example, the proportion of marked 1970 brood fish recovered south of the Columbia River represented more than one-half of the marine recoveries.*

## Introduction

Chinook salmon, *Oncorhynchus tshawytscha*, are the least abundant and largest of the Pacific salmon. Mature fish generally weigh from 10 to 50 pounds; lengths to 4 feet 10 inches and weights as high as 126 pounds have been recorded (Clemens and Wilby, 1961).

Chinook salmon are indigenous to streams of northwestern North America and northeastern Asia. In North America, chinook salmon spawn in streams ranging from the Sacramento River in central California northward along the Pacific coast to the Wulik River which empties into the Arctic Ocean; streams of the Aleutian, Kodiak, Queen Charlotte, and Vancouver Islands; and streams (with remnant runs) of the islands of southeastern Alaska. Chinook salmon spawn in Asian streams from the Anadyr River south along the east coast of the U.S.S.R. to the Amur River, including rivers of the continental coast of the Sea of Okhotsk, east and west coasts of the Kamchatka Peninsula, Komandorskie Islands, and the Japanese Island of Hokkaido (Major et al., 1978; Vronskiy, 1972; and Cleaver, 1969).

The world's largest populations of anadromous chinook salmon are produced in the Columbia River Basin (Fig. 1) which encompasses approxi-

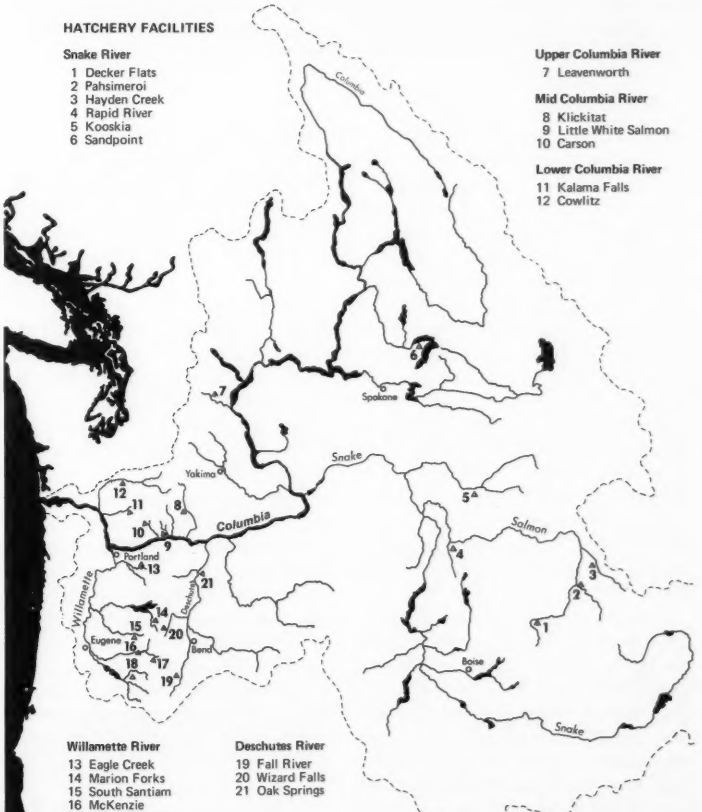



Figure 1.—Location of hatcheries included in the marking study of spring chinook salmon of the 1970 and 1971 broods.

Indian dipnet fisherman at Celilo Falls on the Columbia River. This fishery was conducted for spring chinook salmon as well as for other salmon, prior to the construction of The Dalles Dam which flooded the area.

mately 671,000 km$^2$ (259,000 miles$^2$) of the northwestern United States and southern British Columbia, Canada.

Anadromous chinook salmon annually enter the Columbia River to spawn as 3- to 7-year-old adults. The major spawning migration period extends from February through October. For management purposes, Columbia River Basin chinook salmon traditionally have been classified as spring-, summer-, and fall-run fish corresponding to discrete seasonal peaks in spawning migrations. Spring-run chinook salmon enter the Columbia River in abundance from February through May; summer-run chinook salmon from late May through July; fall-run chinook salmon from early August through October (Chaney and Perry, 1976).

Juvenile chinook salmon emigrate from the Columbia River throughout the year (Rich and Holmes, 1929); the major seaward migration coincides with peak spring runoff, generally April-May. Most juvenile spring chinook salmon live in fresh water for more than 1 year prior to migrating to the ocean. Some summer chinook salmon juveniles live in fresh water for a year or longer, and some migrate before they are 1 year old. Juvenile fall chinook salmon usually migrate after spending only a few months in fresh water.

There is a large body of information documenting the North Pacific Ocean distribution of chinook salmon without reference to areas of origin (Major et al., 1978). Recapture in Columbia River fisheries of chinook salmon tagged when they were maturing adults in the ocean has provided fragmentary insight into the ocean distribution of Columbia River Basin chinook salmon (Davidson and Hutchinson, 1938; Rich, 1939; Silliman, 1948; Parker and Kirkness, 1956; Milne, 1964; Wright, 1968; and Van Hyning, 1973).

Recovery in ocean fisheries of maturing chinook salmon marked when they were juveniles in Columbia River Basin hatcheries has provided additional, but very limited, information on ocean distribution of these stocks. Prior to 1961, most Columbia River Basin hatchery juvenile chinook salmon marking programs involved very small samples, were designed for other purposes, and were conducted in the absence of comprehensive ocean mark recovery programs (Wahle and Vreeland, 1978).

The first comprehensive marking and mark sampling program for Columbia River Basin hatchery-reared chinook salmon was initiated in 1961 and provided extensive information on ocean distribution of fall chinook salmon (Wahle and Vreeland, 1978). No comparable data were available for spring and summer chinook salmon.

In 1971-77 a comprehensive Columbia River Basin hatchery spring chinook salmon marking and mark recovery program was carried out.[1] Approximately 4.1 million juvenile spring chinook salmon of the 1970 and 1971 broods were marked and released in 1971-73. Catches in all major marine fisheries and main-stem Columbia River fisheries, and adults returning to parent hatcheries were sampled for marks in 1972-77.

The results of this study provided the first comprehensive perspective into marine distribution of Columbia River Basin hatchery-reared spring chinook salmon, as well as insight into the relationships among marine and freshwater catches and returns to parent hatcheries.

## Description of the Program

### Salmon Marking (1971-73)

The marking and mark recovery program for spring chinook salmon of the 1970 and 1971 broods included a random sample of juvenile fish from all 21 Columbia River Basin hatcheries rearing spring chinook salmon at the time of the study (Fig. 1). A total of 4,074,821 marked juvenile fish were released, including 2,015,569 juveniles representing approximately 12.5 percent of the 1970 brood and 2,059,252 juveniles representing approximately 13.1 percent of the 1971 brood. Table 1 identifies by hatchery the marks employed, the number of fish marked, and release dates and locations. To simplify the reporting of results, Table 2 and Figures 2 through 7 categorize hatcheries by geographic areas: Lower Columbia, Willamette, Mid-Columbia, Deschutes, Upper Columbia, and Snake River.

[1]Marking was funded by the NMFS Columbia River Fishery Development Program (CRFDP) except at Wizard Falls, Oak Springs, Fall River, and Leaburg. Cooperating with CRFDP were the Canadian Department of Fisheries and Oceans, U.S. Fish and Wildlife Service, and fishery agencies of Oregon, Washington, Idaho, California, and Alaska.

**Table 1.—Marked releases of spring chinook salmon from Columbia River hatcheries, 1970 and 1971 broods.**

| Brood year | Hatchery | Agency[1] | Mark[2] | No. marked (thousands) | Release date | Release location |
|---|---|---|---|---|---|---|
| 1970 | Decker Pond | IFG | D-An | 66.0 | 9-10/71 | Upper Salmon R. |
| | Pahsimeroi Pond | | Ad-D-An | 40.0 | 9/71 | Pahsimeroi R. |
| | Hayden Creek Hatchery | | Ad-D-LV | 52.7 | 10/71 | Lehmi R. |
| | Rapid River Hatchery | | Ad-An | 200.0 | 3-4/72 | Rapid R. |
| | | | Ad-D-RV | 46.0 | 3/72 | Lochsa R. |
| | Sandpoint Hatchery | | Ad-D-RV | 42.7 | 3/72 | |
| | Kooskia Hatchery | USFWS | Ad-An-LV | 54.7 | 3/72 | Clearwater R. |
| | | | Ad-CWT | 41.3 | 3/72 | |
| | Leavenworth Hatchery | | Ad-CWT | 97.0 | 3/72 | Icicle R. |
| | Little White Salmon Hatchery | | D-RV | 48.7 | 1/72 | Little White Salmon R. |
| | Carson Hatchery | | D-RV | 141.7 | 3-4/72 | Wind R. |
| | Eagle Creek Hatchery | | Ad-CWT | 43.5 | 5/72 | Eagle Cr. (Clackamas) |
| | Klickitat Hatchery | WDF | D-RV | 57.7 | 11/71 | Klickitat R. |
| | | | D-RV | 53.8 | 3/72 | |
| | Kalama Falls Hatchery | | Ad-CWT | 27.9 | 9/71 | Kalama R. |
| | | | Ad-CWT | 71.2 | 3/72 | |
| | Cowlitz Salmon Hatchery | | Ad-D | 201.4 | 8/71 | Cowlitz R. |
| | | | Ad-D | 95.3 | 11/71 | |
| | | | Ad-D | 92.8 | 2/72 | |
| | Wizard Falls Hatchery | ODFW | LV-RP | 61.0 | 3/72 | Deschutes R. |
| | Oak Springs Hatchery | | RV-LP | 52.7 | 3/72 | |
| | Leaburg Hatchery | | D-RP | 100.5 | 3-4/72 | McKenzie R. |
| | McKenzie Hatchery | | D-LV | 12.1 | 12/71 | |
| | | | D-LV | 17.0 | 3/72 | |
| | South Santiam Hatchery | | D-LV | 23.5 | 11/71 | South Santiam R. |
| | | | D-LP | 20.8 | 11/71 | |
| | | | D-RP | 19.9 | 11/71 | South Santiam (Foster Res.) |
| | Marion Forks Hatchery | | D-LV | 98.4 | 4/72 | North Santiam R. |
| | Willamette Hatchery | | D-LV | 24.2 | 11/71 | Willamette R. |
| | Dexter Holding Ponds | | D-LV | 111.1 | 3/72 | |
| 1971 | Decker Pond | IFG | Ad-An-LV | 30.0 | 9/72 | Upper Salmon R. |
| | | | Ad-An-RV | 30.0 | 10/72 | |
| | Pahsimeroi Pond | | An-LV | 52.5 | 5/72 | Pahsimeroi R. |
| | | | An-RV | 45.8 | 10/72 | |
| | Hayden Creek Hatchery | | RV-LM | 73.7 | 10/72 | Lemhi R. |
| | Rapid River Hatchery | | Ad-An | 201.2 | 3/73 | Rapid R. |
| | Kooskia Hatchery | USFWS | Ad-D-An | 52.6 | 10/72 | Clearwater R. |
| | | | D-An | 101.3 | 3/73 | |
| | Leavenworth Hatchery | | Ad-D-RV | 50.1 | 4/73 | Icicle R. |
| | | | Ad-D-LV | 49.3 | 4/73 | |
| | Little White Salmon Hatchery | | Ad-RV | 123.4 | 4/73 | Little White Salmon R. |
| | Carson Hatchery | | Ad-LV | 163.3 | 4/73 | Wind R. |
| | Eagle Creek Hatchery | | D-LV-RV | 99.8 | 5/73 | Eagle Cr. (Clackamas R.) |
| | Klickitat Hatchery | WDF | Ad-D | 47.3 | 11/72 | Klickitat R. |
| | | | Ad-D | 43.6 | 3/73 | |
| | Kalama Falls Hatchery | | Ad-CWT | 35.1 | 9/72 | Kalama R. |
| | | | Ad-CWT | 28.4 | 4/73 | |
| | Cowlitz Hatchery | | Ad-CWT | 35.4 | 9/72 | Cowlitz R. |
| | | | Ad-CWT | 91.7 | 11/72 | |
| | | | Ad-CWT | 26.5 | 2/73 | |
| | | | Ad-CWT | 46.2 | 4/73 | |
| | Fall River Hatchery | ODFW | LV-RV | 117.9 | 3/73 | Deschutes R. |
| | Leaburg Hatchery | | RV-RM | 100.0 | 4/73 | McKenzie R. |
| | McKenzie Hatchery | | D-RV | 29.9 | 3/73 | |
| | South Santiam Hatchery | | D-LV | 47.1 | 11-12/73 | South Santiam R. |
| | | | D-RV | 3.5 | 3/73 | |
| | Marion Forks Hatchery | | D-RV | 102.5 | 4/73 | North Santiam R. |
| | Willamette Hatchery | | D-LV | 54.8 | 1/73 | Willamette R. |
| | | | D-RV | 33.8 | 4/73 | McKenzie R. |
| | | | D-RV | 119.5 | 3/73 | Willamette R. |

[1]Acronyms designate the following agencies: IFG, Idaho Fish and Game Department; USFWS, U.S. Fish and Wildlife Service; WDF, Washington Department of Fisheries; and ODFW, Oregon Department of Fish and Wildlife.
[2]Mark abbreviations are as follows: Ad, adipose; An, anal; LV, left ventral; RV, right ventral; LM, left maxillary; D, dorsal; CWT, coded wire tag; RM, right maxillary; RP, right pectoral; and LP, left pectoral fin.

**Table 2.—Marine and Columbia River fisheries - hatchery recoveries of marked spring chinook salmon of the 1970 and 1971 broods, by hatchery area of release.**

| Brood year | Hatchery area of release | Recoveries: Marine No. | Marine Percent | Columbia River fishery No. | Columbia River fishery Percent | Hatchery No. | Hatchery Percent | Total |
|---|---|---|---|---|---|---|---|---|
| 1970 | Lower Columbia | 6,942 | 77.9 | 662 | 7.4 | 1,306 | 14.7 | 8,910 |
| | Willamette | 413 | 33.2 | 420 | 33.8 | 410 | 33.0 | 1,243 |
| | Mid-Columbia | 42 | 19.8 | 98 | 46.2 | 72 | 34.0 | 212 |
| | Deschutes | 155 | 21.7 | 360 | 50.5 | 198 | 27.8 | 713 |
| | Upper Columbia | 60 | 6.9 | 593 | 68.5 | 213 | 24.6 | 866 |
| | Snake River | 264 | 65.2 | 43 | 10.6 | 98 | 24.2 | 405 |
| | Total | 7,876 | — | 2,176 | — | 2,297 | — | 12,349 |
| | Average | — | 63.8 | — | 17.6 | — | 18.6 | — |
| 1971 | Lower Columbia | 5,404 | 73.6 | 106 | 1.4 | 1,828 | 24.9 | 1,338 |
| | Willamette | 457 | 67.1 | 22 | 3.2 | 202 | 29.7 | 681 |
| | Mid-Columbia | 952 | 52.7 | 33 | 1.8 | 823 | 45.5 | 1,808 |
| | Deschutes | 377 | 87.9 | 37 | 8.6 | 15 | 3.5 | 429 |
| | Upper Columbia | 5 | 55.6 | 0 | 0 | 4 | 44.4 | 9 |
| | Snake River | 260 | 38.5 | 26 | 3.8 | 390 | 57.7 | 676 |
| | Total | 7,455 | — | 224 | — | 3,262 | — | 10,941 |
| | Average | — | 68.1 | — | 2.1 | — | 29.8 | — |

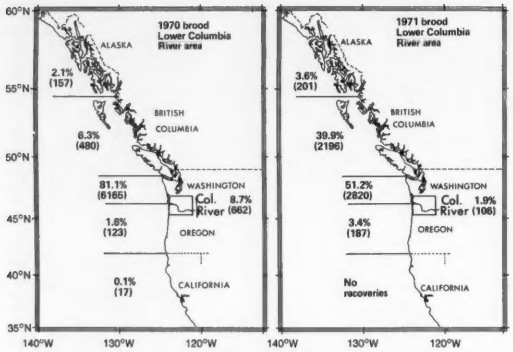



Figure 2.—The relative distribution, among major fisheries, of recovered, marked, spring chinook salmon released from the Lower Columbia hatchery area (number of recovered fish in parentheses).

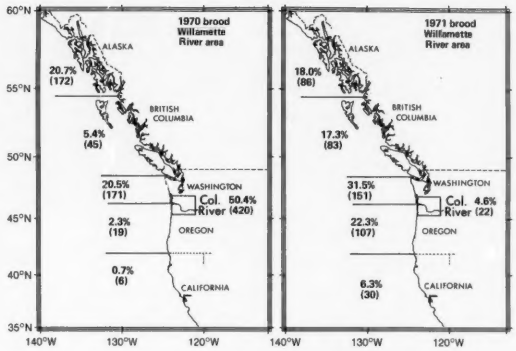



Figure 3.—The relative distribution, among major fisheries, of recovered, marked, spring chinook salmon released from the Willamette hatchery area (number of recovered fish in parentheses).

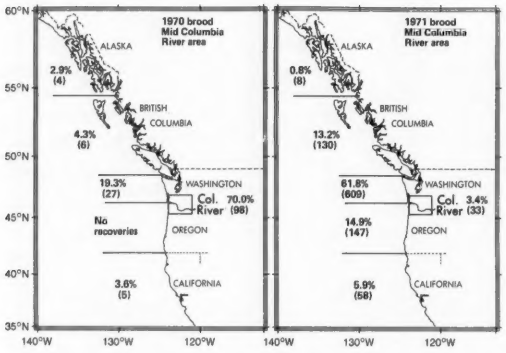



Figure 4.—The relative distribution, among major fisheries, of recovered, marked, spring chinook salmon released from the Mid-Columbia hatchery area (number of recovered fish in parentheses).

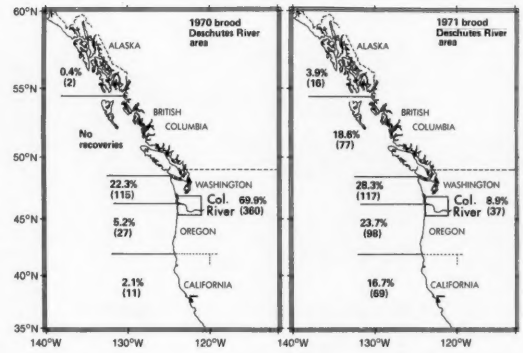



Figure 5.—The relative distribution, among major fisheries, of recovered, marked, spring chinook salmon released from the Deschutes River hatchery area (number of recovered fish in parentheses).

## Recovery of Marked Fish (1972-77)

Catches in all major marine sport and commercial fisheries from Monterey, Calif., north to Pelican, Alaska (including Puget Sound fisheries), were sampled for marks as were catches in main-stem Columbia River fisheries and returns to hatcheries. The recovery phase of this study (1972-77) resulted in the recovery of a total of 23,290 1970 and 1971 brood marked fish: 15,331 in marine fisheries, 2,400 in main-stem Columbia River fisheries, and 5,559 at parent hatcheries (Table 2). A total of 12,349 1970 brood marked fish were recovered: 7,876 in marine fisheries, 2,176 in main-stem Columbia River fisheries, and 2,297 at parent hatcheries.

Figures 2 through 7 display by geographic area of origin the number and percentage of 1970 and 1971 brood marked fish recovered in major marine and main-stem Columbia River fisheries. Of the 1970 brood, 10,052 marked fish were recovered in fisheries (Table 3); the largest number, 6,606, was recovered in catches sampled in marine ports and zones of the State of Washington (Fig. 8). The smallest number, 84, was recovered in catches sampled at marine ports in the State of California.

Table 2 summarizes by geographic area of origin the number and percentage of the total 1970 brood marked fish

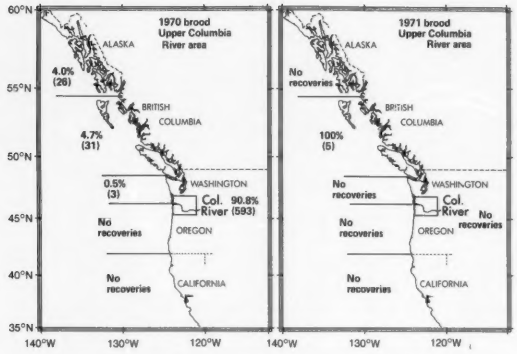



Figure 6.—The relative distribution, among major fisheries, of recovered, marked, spring chinook salmon released from the Upper Columbia River hatchery area (number of recovered fish in parentheses).

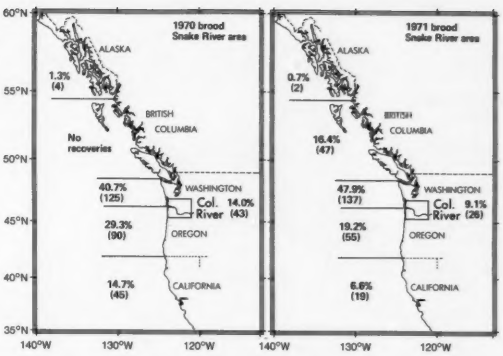



Figure 7.—The relative distribution, among major fisheries, of recovered, marked, spring chinook salmon released from the Snake River hatchery area (number of recovered fish in parentheses).

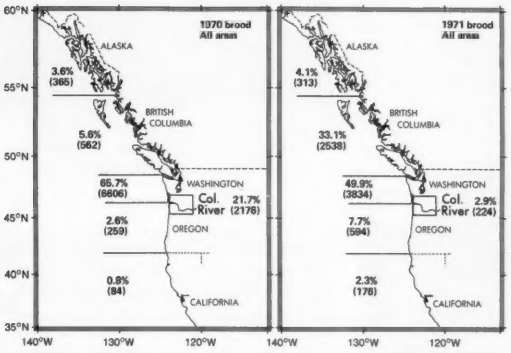



Figure 8.—The relative distribution, among major fisheries, of recovered, marked, spring chinook salmon released from all hatchery areas (number of recovered fish in parentheses).

Troller off Noyes Island, Alaska, a northern recovery location for some Columbia River spring chinook salmon.

recovered in all marine and main-stem Columbia River fisheries and at parent hatcheries. Table 3 presents by hatchery of origin the number of 1970 brood marked fish recovered in major fisheries and at parent hatcheries.

A total of 10,941 1971 brood marked fish were recovered: 7,455 in marine fisheries, 224 in main-stem Columbia River fisheries, and 3,262 at parent hatcheries. Of the 7,679 fish recovered in fisheries the largest number, 3,837, was recovered in catches sampled in marine ports and zones of the State of Washington (Fig. 8). The smallest number, 176, was recovered in catches sampled at marine ports in California.

Table 2 summarizes by geographic area of origin the number and percentage of the total 1971 brood marked fish recovered in all marine and main-stem Columbia River fisheries and at parent hatcheries. Table 4 presents by hatchery of origin the number of 1971 brood fish recovered in major fisheries and at parent hatcheries.

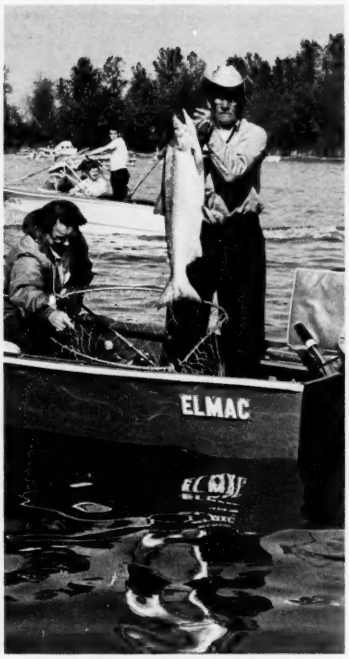
### Factors That Limit Use of Data

The data obtained as the result of this marking and mark recovery program provided the most comprehensive perspective available to date on ocean distribution of Columbia River Basin hatchery-reared spring chinook salmon as well as insight into the relationships

**Table 3.—Mark recoveries of 1970 brood spring chinook salmon, by hatchery and fishery area.**

| Hatchery | Date released from hatchery | Marine fishery area | | | | | Columbia River fishery | Hatchery returns | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Alaska | B.C. | Wash. | Oregon | Calif. | | | |
| | | Number of fish | | | | | | | |
| Lower Columbia | | | | | | | | | |
| Cowlitz | 8/71, 11/71, 2/72 | 78 | 38 | 3,084 | 80 | 17 | 364 | 900 | 4,561 |
| Kalama Falls | 9/71 | 62 | 405 | 2,968 | 43 | 0 | 245 | 386 | 4,109 |
| Kalama Falls | 3/72 | 17 | 37 | 113 | 0 | 0 | 53 | 20 | 204 |
| Willamette River | | | | | | | | | |
| Common mark[1] from 5 stations | 11/71, 3/72, 4/72 | 138 | 0 | 117 | 10 | 2 | 279 | 309 | 855 |
| South Santiam and Leaburg | 11/71, 3/72, 4/72 | 2 | 0 | 9 | 5 | 0 | 12 | 34 | 62 |
| South Santiam | 11/71 | 2 | 0 | 26 | 0 | 0 | 53 | 34 | 115 |
| Eagle Creek | 5/72 | 30 | 45 | 19 | 4 | 4 | 76 | 15 | 193 |
| Mid-Columbia | | | | | | | | | |
| Common mark[2] 3 hatcheries | 11/71, 3/72, 4/72, 7/72 | 4 | 6 | 27 | 0 | 5 | 98 | 72 | 212 |
| Deschutes River | | | | | | | | | |
| Oak Springs | 3/72 | 0 | 0 | 109 | 27 | 11 | 236 | 112 | 495 |
| Wizard Falls | 3/72 | 2 | 0 | 6 | 0 | 0 | 124 | 86 | 218 |
| Upper Columbia | | | | | | | | | |
| Leavenworth | 3/72 | 26 | 31 | 3 | 0 | 0 | 593 | 213 | 866 |
| Snake River | | | | | | | | | |
| Lochsa | 3/72 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kooskia | 3/72 | 0 | 0 | 13 | 6 | 27 | 2 | 0 | 48 |
| Rapid River | 3-4/72 | 4 | 0 | 78 | 84 | 18 | 37 | 82 | 303 |
| Hayden Creek | 10/71 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 8 |
| Pahsimeroi Pond | 9/71 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Decker Pond | 9-10/72 | 0 | 0 | 34 | 0 | 0 | 0 | 10 | 44 |
| Total | | 365 | 562 | 6,606 | 259 | 84 | 2,176 | 2,279 | 12,331 |

[1]McKenzie, South Santiam, Marion Forks, Willamette, and Dexter.
[2]Carson, Little White Salmon, and Klickitat.




Boat anglers with a spring chinook salmon taken in Multnomah Channel at the mouth of the Willamette River.

**Table 4.—Mark recoveries of 1971 brood spring chinook salmon, by hatchery and fishery area.**

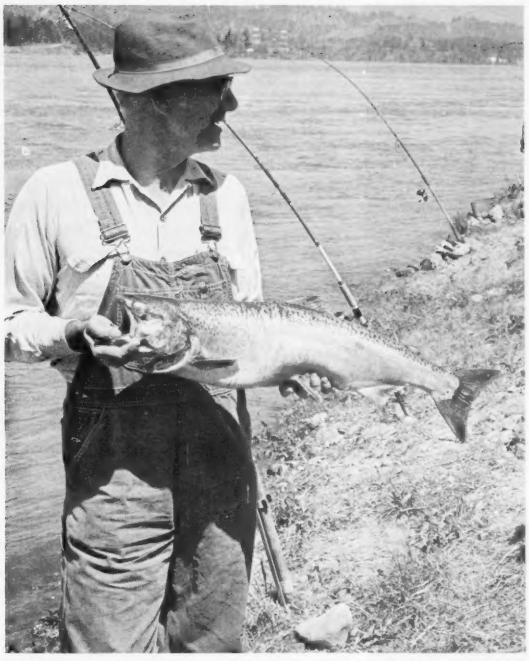
| Hatchery | Date released from hatchery | Marine fishery area | | | | | Columbia River fishery | Hatchery returns | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Alaska | B.C. | Wash. | Oregon | Calif. | | | |
| | | Number of fish | | | | | | | |
| Lower Columbia | | | | | | | | | |
| Cowlitz | 9/72 | 13 | 105 | 76 | 7 | 0 | 26 | 78 | 305 |
| Cowlitz | 11/72 | 17 | 70 | 139 | 4 | 0 | 2 | 113 | 345 |
| Cowlitz | 2/73 | 24 | 517 | 725 | 21 | 0 | 10 | 388 | 1,685 |
| Cowlitz | 4/73 | 37 | 834 | 1,713 | 155 | 0 | 29 | 768 | 3,536 |
| Kalama Falls | 9/72 | 28 | 93 | 39 | 0 | 0 | 26 | 67 | 253 |
| Kalama Falls | 4/73 | 82 | 577 | 128 | 0 | 0 | 13 | 414 | 1,214 |
| Willamette River | | | | | | | | | |
| Common mark[1] 4 hatcheries | 3-4/73 | 23 | 0 | 9 | 16 | 0 | 2 | 48 | 98 |
| Willamette and So. Santiam | 11-12/72 | 61 | 76 | 130 | 43 | 17 | 13 | 135 | 475 |
| Leaburg | 4/73 | 0 | 7 | 3 | 37 | 13 | 0 | 0 | 60 |
| Eagle Creek | 4/73 | 2 | 0 | 9 | 11 | 0 | 7 | 19 | 48 |
| Mid-Columbia | | | | | | | | | |
| Carson | 4/73 | 4 | 3 | 200 | 67 | 38 | 19 | 299 | 630 |
| Little White Salmon | 4/73 | 2 | 0 | 168 | 44 | 20 | 2 | 502 | 738 |
| Klickitat | 11/72, 3/73 | 2 | 127 | 241 | 36 | 0 | 12 | 22 | 440 |
| Upper Columbia | | | | | | | | | |
| Leavenworth | 4/73 | 0 | 5 | 0 | 0 | 0 | 0 | 4 | 9 |
| Deschutes River | | | | | | | | | |
| Fall River | 3/73 | 16 | 77 | 117 | 98 | 69 | 37 | 15 | 429 |
| Snake River | | | | | | | | | |
| Kooskia | 10/72, 3/73 | 0 | 0 | 0 | 0 | 0 | 0 | 53 | 53 |
| Rapid River | 3/73 | 2 | 9 | 42 | 7 | 0 | 26 | 292 | 378 |
| Hayden Creek | 10/72 | 0 | 4 | 24 | 33 | 9 | 0 | 9 | 79 |
| Pahsimeroi Pond | 5/72, 9/72 | 0 | 28 | 50 | 6 | 0 | 0 | 36 | 120 |
| Decker Pond | 9-10/72 | 0 | 6 | 21 | 9 | 10 | 0 | 0 | 46 |
| Total | | 313 | 2,538 | 3,834 | 594 | 176 | 224 | 3,262 | 10,941 |

[1]McKenzie, South Santiam, Marion Forks, and Willamette.

among marine and freshwater catches and returns to parent facilities. Several factors severely limit use of the data for other purposes:

1) The large number and variety of marks employed (both finclips and the newer coded wire tags were used) significantly complicated mark recovery sampling and may have affected the reliability of sampling.

2) The 1970 brood Kalama Falls fish were the first Columbia River Basin salmon marked with binary numbered, coded wire tags; the 1970 brood Leavenworth, Kooskia, and Eagle Creek fish were the first marked with color coded wire with the intent of having them recovered in marine fisheries. During the first year of the mark recovery program only the State of Washington was organized to sample effectively for these tags; sampling for these tags was organized coastwide during the second year of the mark recovery program but un-



Bank anglers fishing for spring chinook salmon in the Columbia River near Bonneville Dam.

Columbia River gillnetter with a spring chinook salmon taken near Puget Island, Wash.

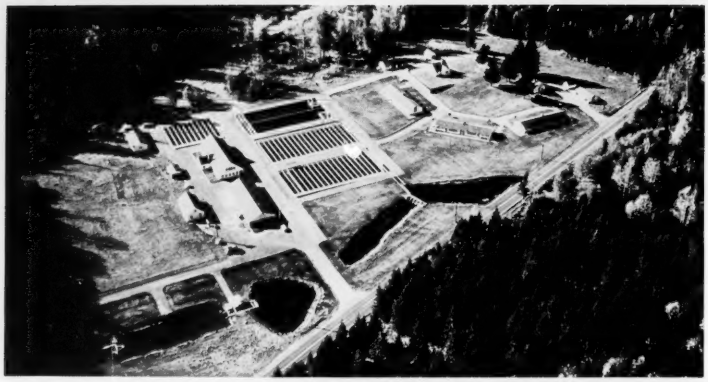
doubtedly suffered problems typical of first-year programs.

3) There was significant, but unquantified, induced mortality associated with marking; the differential mortality associated with various marks makes it impossible either to reach meaningful conclusions about survival of marked fish and their contribution to fisheries or to make meaningful comparisons among lots of fish bearing different marks.

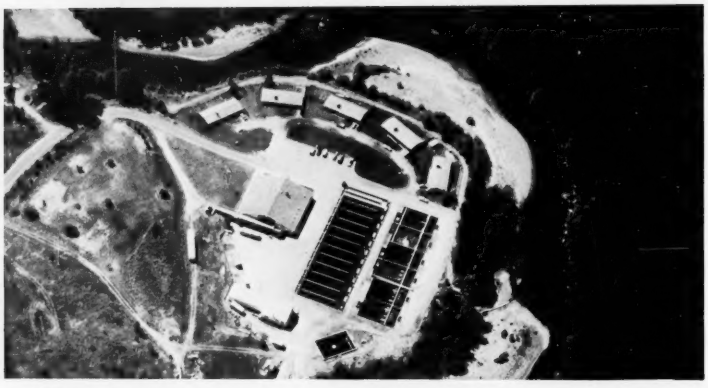
4) There have been major changes in ocean fishing seasons during and subsequent to the mark recovery phase of this program. These changes could affect the reliability of directly extrapolating the results of this study to the present time.

5) Juvenile salmon and steelhead migrants originating in production areas above Bonneville Dam at river mile 146.1 incur extensive mortalities at main-stem hydroelectric projects; there was a significant, but unquantified, vari-

Anglers on a "hog line" fishing for spring chinook salmon in the Willamette River near Oregon City.



Carson National Fish Hatchery on the Wind River in Washington.



Kalama Falls Hatchery (operated by the Washington Department of Fisheries) on the Kalama River.

Marion Forks Hatchery (operated by the Oregon Department of Fish and Wildlife) on the North Santiam River.

-ance in mortalities imposed upon the 1970 and 1971 brood juvenile hatchery spring chinook originating from areas above Bonneville Dam (i.e., Mid-Columbia, Deschutes River, Upper Columbia, and Snake River production areas). Varying mortality rates at mainstem hydroelectric projects in subsequent years make it impossible to extrapolate meaningfully to date the relative survival and contribution to fisheries of hatchery spring chinook salmon from these areas or to make meaningful comparisons between these production areas and the Lower Columbia and Willamette production areas.

6) Adult salmon and steelhead migrants originating in production areas above Bonneville Dam also suffer extensive mortalities at main-stem hydroelectric projects. In addition, in-river straying of adult fish is known to occur, but the significance of this phenomenon to the results of this study is not known. Both factors reduce to an unknown extent the number of marked fish recovered in-river and, thereby, inflate to an unknown extent the percentage of the total marked fish recovered in marine fisheries.

Individually and collectively, these six factors would 1) significantly affect the reliability of the mark recovery data in this report for purposes other than general perspective on the relative ocean distribution of Columbia River Basin hatchery spring chinook salmon and 2) affect insights into the relationships among marine and freshwater catches and adult returns to parent hatcheries at the time of the study. Nonetheless, these mark recovery data provide the basis for additional general observations of potential value to fishery managers and researchers.

### Marine Distribution North and South of Columbia River

The majority of the marked fish recovered in marine fisheries were taken off Alaska, British Columbia, and Washington (Fig. 8). This distribution is consistent with the traditional view that Columbia River Basin spring chinook salmon generally distribute themselves predominantly north of the Columbia River mouth, at least during the time

they are most susceptible to marine fisheries.

Expressed as a percentage of the total number of marked fish recovered in marine fisheries, recoveries south of the Columbia River (i.e., off California and Oregon) were 4.4 percent for marked fish of the 1970 brood and 10.3 percent for marked fish of the 1971 brood (Fig. 8).

When the mark recoveries are disaggregated by area of origin (Fig. 2-7), however, some hatchery production areas evince a contribution to marine fisheries south of the Columbia River mouth which contrasts rather sharply with the traditional generalized view. For example, in Figure 7, the total number of 1970 brood Snake River marked fish recovered off Oregon and California represents 51 percent of the total 1970 brood Snake River marks recovered in marine fisheries. The total number of 1971 brood Deschutes marks recovered in Oregon and California marine fisheries represents 44 percent of total 1971 brood Deschutes marks recovered in marine fisheries (Fig. 5).

### Marine, River, and Hatchery Recoveries

Table 2 lists by geographic area of origin the total number of marked fish of the 1970 and 1971 broods recovered in marine fisheries, main-stem Columbia River fisheries, and at parent hatchery facilities. In the aggregate, 63.8 percent of the total 1970 brood marked fish and 68.1 percent of the total 1971 brood marked fish recovered were taken in marine fisheries. These data suggest that at the time of the mark recovery program, the majority of Columbia River Basin hatchery spring chinook salmon contributed to marine fisheries at a significantly higher rate than traditionally believed.[2]

The percentage of marked fish recovered in marine fisheries as compared to the in-river fishery and hatchery returns varied greatly among major hatchery production areas; the range was from 6.9 percent for the Upper Columbia 1970 brood to 87.9 percent for the 1971 brood Deschutes River marked fish recovered. This wide variance suggests significant potential for hatchery stock selection to distribute strategically Columbia River Basin hatchery spring chinook salmon between marine and in-river fisheries.

The percentage of marked fish recovered in marine fisheries north and south of the Columbia River also varied among major hatchery production areas. This variance suggests potential for hatchery stock selection to distribute strategically Columbia River Basin hatchery spring chinook salmon among marine fisheries.

### Literature Cited


Chaney, E., and L. E. Perry. 1976. Columbia Basin salmon and steelhead analysis. Summ. Rep. Pac. Northwest Regional Comm., Vancouver, Wash., 74 p.

Cleaver, F. C. 1969. Effects of ocean fishing on 1961-brood fall chinook salmon from Columbia River hatcheries. Res. Rep. Fish Comm. Oreg. 1, 76 p.

Clemens, W. A., and G. V. Wilby. 1961. Fishes of the Pacific Coast of Canada. Fish. Res. Board Can., Bull. 68, 443 p.

Davidson, F. A., and S. J. Hutchinson. 1938. The geographic distribution and environmental limitations of the Pacific salmon (Genus *Oncorhynchus*). Bull. (U.S.) Bur. Fish 48:667-692.

Major, R. L., J. Ito, S. Ito, and H. Godfrey. 1978. Distribution and origin of chinook salmon (Oncorhynchus tshawytscha) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm., Bull. 38, 54 p.

Milne, D. J. 1964. The chinook and coho salmon fisheries of British Columbia. Fish. Res. Board Can., Bull. 142, 46 p.

Parker, R. R., and W. Kirkness. 1956. King salmon and the ocean troll fishery of southeastern Alaska. Res. Rep. Alaska Dep. Fish. 1, 64 p.

Rich, W. H. 1939. Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska. Fish Comm. Oreg., Contrib. 1, 50 p.

Rich, W. H., and H. B. Holmes. 1929. Experiments in marking young chinook salmon on the Columbia River, 1916 to 1927. Bull. (U.S.) Bur. Fish. 44:215-264

Silliman, R. P. 1948. Estimation of the troll catch of Columbia River chinook salmon, *Oncorhynchus tschawytscha*. U.S. Fish Wildl. Serv., Spec. Sci. Rep. 50, 15 p.

Van Hyning, J. M. 1973. Factors affecting the abundance of fall chinook salmon in the Columbia River. Res. Rep. Fish Comm. Oreg. 4, 87 p.

Vronskiy, B. B. 1972. Materialy o razmnozhenii chavychi *Oncorhynchus tschawytscha* (Walbaum) r. kamchatki (Some data on the reproduction of the Kamchatka chinook salmon *Oncorhynchus tshawytscha* (Walbaum).) Vopr. Ikhtiol. 12:293-308. [In Russ.] (Transl. in J. Ichthyol., 1972, 12:259-273.)

Wahle, R. J., and R. R. Vreeland. 1978. Bioeconomic contribution of Columbia River hatchery fall chinook salmon, 1961 through 1964 broods, to the Pacific salmon fisheries. Fish. Bull., U.S. 76:179-208.

Wright, S. G. 1968. Origin and migration of Washington's chinook and coho salmon. Wash. State Dep. Fish., Inf. Booklet 1, 25 p.


[2]Reflecting the prevailing lack of data, a 1980 poll of State and Federal fishery agencies operating within the Columbia River Basin found estimated marine catch rates (all fisheries) on Columbia River spring chinook salmon ranging from 12.5 to 50 percent of the total catch plus hatchery returns.

# Deepwater Shrimp Resources in Vanuatu: A Preliminary Survey off Port Vila

MICHAEL G. KING

## Introduction

Natantian decapod custaceans represent one of the world's most commercially valuable group of marine species. This group consists of two large subgroups: 1) Penaeid shrimps which form the basis of valuable trawl fisheries in many tropical and subtropical countries, and 2) carid shrimps, which are more widely distributed but less commonly exploited. Interest in the exploitation of deepwater carid shrimps has recently developed, however.

Carid biology is not well known, although a few species, which form the basis of commercial fisheries, have been studied. Many carids are deepwater, benthic species living on the sea floor and may make vertical diel migrations up into the mid-water masses. The females carry the eggs externally (in contrast with penaeid shrimps) under the abdomen on the pleopods, which are especially adapted for the purpose. The life cycle of carid shrimps appears to be more extended than that of most penaeids.

Carids are caught commercially off Alaska (Barr, 1970), California (Dahlstrom, 1970), and Chile (Hancock and Henriquez, 1968). In several other areas experimental trapping for deepwater shrimps has been carried out: Hawaii (Struhsaker and Aasted, 1974), Guam (Wilder, 1977), New Caledonia (Intès, 1978), Fiji (Brown and King, 1979), and Western Samoa (King, 1980).

The distribution of deepwater carids in the above countries suggests that similar resources may exist in other Pacific Islands with suitable offshore bathymetry. This preliminary survey was undertaken in April 1980 to examine deepwater shrimp resources near Vanuatu (previously known as the New Hebrides).

Vanuatu, including the Banks and Torres group of islands, consists of about 40 mountainous islands, besides numerous islets and rocks. They lie approximately between lat. 13° and 20½°S and long. 166½° and 170°E (Fig. 1). Vanuatu appears to be situated on a bank with depths of about 650-750 m and which runs approximately in a northwest to southeast direction (Pacific Islands Pilot, 1969).

Vanuatu is of volcanic origin and coral formations are generally restricted to isolated and fringing reefs rather than barrier reefs. In many islands, depths drop to over 200 m within less than 1 n.mi. from the coast. For logistic reasons,

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*ABSTRACT—Baited traps were used to survey deepwater shrimps in Vanuatu in the Southwestern Pacific. Two-entrance box traps (some covered with hessian sacking; the others uncovered) were set in depths from 229 m to 650 m out from Port Vila. Shrimp catch weight did not differ significantly between covered and uncovered traps but differed markedly with depth. Mean catch rates varied from 0.04 kg per trap in the 200-300 m depth range to 2.83 kg per trap in the 500-600 m depth range. Seven species of carid shrimp were provisionally identified from the catch. In terms of abundance,* Plesionika longirostris, Heterocarpus ensifer, *and* H. laevigatus *had the greatest commercial potential.*

Ovigerous specimens of *Plesionika longirostris.*

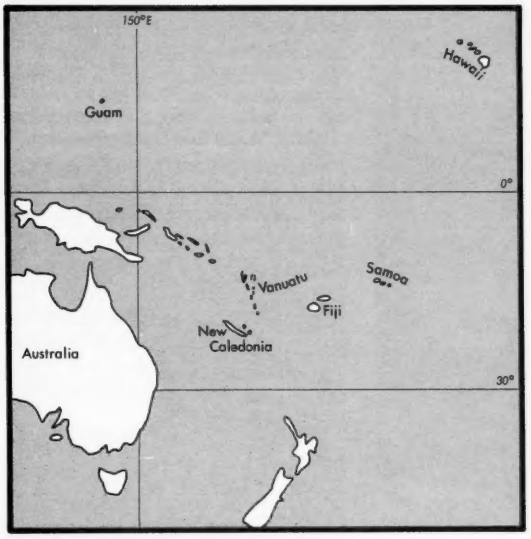



Figure 1.—Vanuatu and other island countries mentioned in the text.

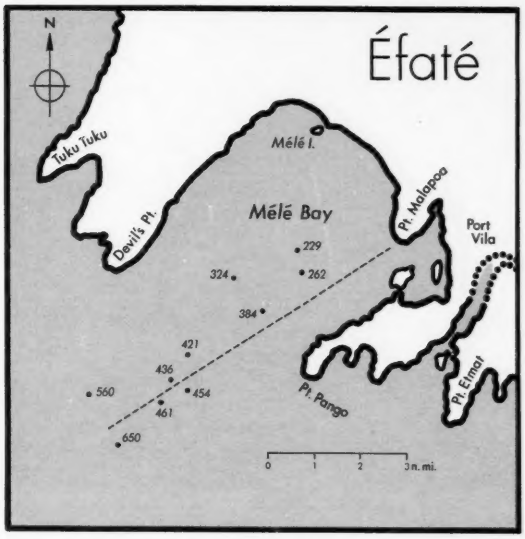



Figure 2.—The survey area near Port Vila. The position of the depth profile presented in the results (Fig. 5) is indicated by the broken line. Trapping locations are marked with black dots and the depth in meters. (Source: Chart 4787, Service Hydrographique de la Marine, Paris.)

the preliminary survey was confined to waters adjacent to Port Vila the capital of Vanuatu on the Island of Éfaté (Fig. 2).

Éfaté is a mountainous island, especially in the northwest, with Mount Macdonald reaching 672 m, and sloping down to Éfaté Bay on the southern part of the island. Port Vila is a well sheltered harbor on the inner (northeast) part of Mélé Bay.

## Fishing Gear and Methods

### Traps

The basic trap design was that of a box 80×70 cm and 40 cm deep (Fig. 3). The trap framework was welded from 8 mm diameter steel rod, reinforced by two diagonal cross bars on the base and one longitudinal rod, to which the access gate was hinged on the top. The entry cones at each end were tapered in from the edges and extended about 24 cm into the interior of the trap. The inner opening of the cone was 10 cm in diameter.

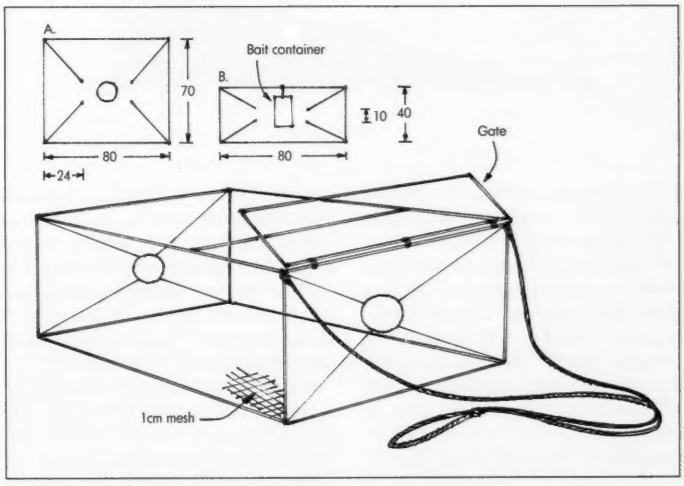



Figure 3.—The basic trap design used in the survey. A and B represent the top plan and the side view of the trap, respectively.

The trap frames and cones were covered with molded plastic screen with an oval mesh size of 10 mm maximum diameter. On about one-third of the traps,

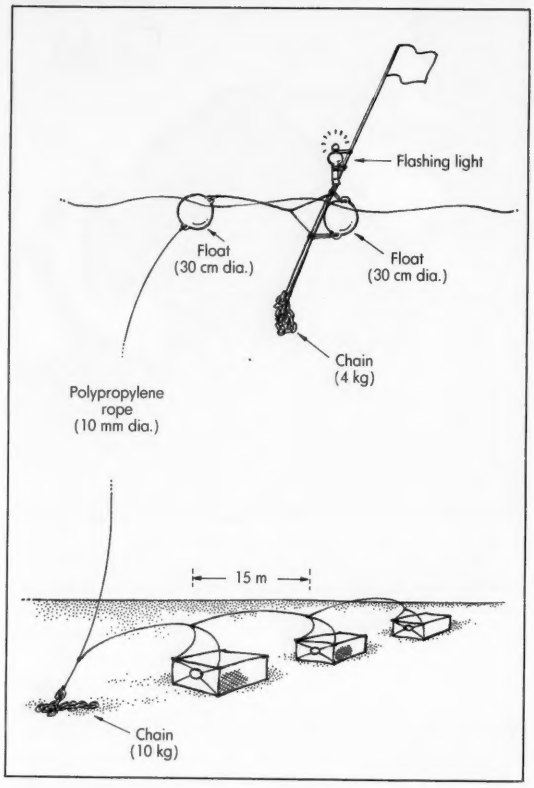



Figure 4.—The arrangement of the trap fishing rig used in the survey. The length of drop line used (i.e., between buoys and bottom weight) was equivalent to the depth of the water plus an excess of 25 percent (minimum).

the sides, bottoms, and tops (i.e., excluding the cones) were covered with hessian sacking. It has been claimed that "covered" traps (i.e., covered with hessian or burlap) are more efficient in catching shrimp than "uncovered" traps (Struhsaker and Aasted, 1974). Reasons for this could include the hessian cover, either concentrating substances from the bait at the entrances of the traps, or providing additional shelter for the shrimps (i.e., acting as "habitat" traps).

### The Fishing Rig

The trap fishing line consisted of two parts: A drop line from the marker buoys and a bottom line from which the traps were strung (Fig. 4). The top of the drop line was attached to a 30 cm diameter buoy which was itself attached to a second marker buoy. The second marker buoy was lashed to a 3 m wood or bamboo pole fitted with a brightly colored flag and a 4 kg scrap chain weight (Fig. 4). The buoy was attached approximately 1.8 m from the top of the pole. A "man-overboard" flashing light was attached to the pole above the buoy.

The drop line was of 10 mm diameter polypropylene and was made from coils (about 210 m in length) which were joined together as necessary. At one end of the bottom line, 4 loops were spliced into the rope at 15 m intervals, the last loop being an eyesplice at the end of the rope. This spacing was incorporated to decrease competitive effects between the traps. The last three loops were used to attach the trap lines and, from the fourth loop, a 10 kg weight was attached via a short length of rope to prevent the traps from being lifted by the pressure of wind and current against the floats and rope.

### Fishing Vessel and Equipment

The boat used was a 8.5 m wood and plywood catamaran powered by a 25 h.p. (18.7 kw) outboard engine. The winch concisted of a 3 h.p. Briggs and Stratton[1] 4-stroke engine which powered a geared trap hauler via a belt drive. The trap hauler was of the type used in the Australian rock lobster trapping fishery (i.e., in which the trap line is firmly gripped by a pulley, and stripped off by a metal peeler).

A skipper model 603 echo sounder fitted with a narrow-beam ferrite transducer was used to obtain depth profiles and measure the depth at each trap drop. The echo sounder was rigged as a portable unit with a separate 12-volt lead-acid battery and the transducer was mounted on the end of a length of pipe. A hand compass was used to fix the position from shore marks at each drop location.

### Bait

I intended to use the same bait throughout the survey, preferably skipjack tuna, *Katsuwonus pelamis,* as this was the most successful of several baits tested in Fiji[2]. However tuna was not always available in Vanuatu and, in the initial trap sets, a variety of baits was used including bonefish, *Albula vulpes;* Indian mackerel, *Rastrelliger kanagurta;* and sardines, *Sardinella* spp. Sardines were the most easily obtained local bait and this species was used throughout the remainder of the survey. About 500 g of bait was placed in plastic netting containers (about 10 mm mesh size) and suspended in the center of each trap (Fig. 3).

### The Fishing Operation

Except during the initial trap construction stage and during certain peri-

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.
[2]King, M. G. University of the South Pacific, P. O. Box 1168, Suva, Fiji. Unpubl. data.

ods of maintenance, two strings of three traps each were used. Each string of traps was left in the sea overnight and hauled in, emptied, and rebaited before being reset in a new location on the following day.

At each location the traps and weight were lowered over the windward side of the boat. With the motor off, the boat would drift off to leeward with the trap acting as a sea anchor during the drop. Pressure was always kept on the drop line as the ropes were let out to avoid tangling the traps. On the rare, windless days, the boat's motor was used at the lowest possible speed to keep the pressure on the drop line. During the drop, additional coils of rope or half coils were successively added to the drop line to provide sufficient rope for the depth of water (equivalent to the depth of water plus a minimum of 25 percent). At the end of the coil, the float buoy and marker buoy were attached and cast off from the boat.

On the following morning, the recorded landmarks were used to locate the marker buoy. Rope was hauled in and flayed down in bins or directly into the catamaran floats. Once on deck, the catch from each trap was placed in separate plastic bags and labelled before storing on ice.

### Survey Area and Method

Initial depth soundings were made in several areas and a full depth profile was recorded along a transect running out at 238° true bearing from Point Malapoa in Mélé Bay (Fig. 1).

The survey was conducted by setting traps at various depths along the transec' Two strings of three traps were intended to be set over each night in predetermined depths (at 50 m depth intervals) from 200 to 700 m, but the program had to be modified due to gear and weather problems.

At each set location the depth was recorded both at the time of setting and hauling; the mean of these was used to define the "estimated fishing depth." Also, at each set location, a hand compass was used to record the bearings of shore marks. These and other details were recorded at sea on a daily log sheet.

The catch from each individual trap was placed in a labelled plastic bag and stored in a portable ice box. Once ashore, shrimp were separated according to species and into ovigerous (egg-bearing) and nonovigerous groups, before being counted and weighed. A large sample, usually the catch from one trap in each string, was set aside for measuring. Shrimp carapace lengths (distance between the postorbital eye socket and the posterior median edge of the cephalothorax) were recorded to the nearest millimeter.

The FAO-designed catamaran used in the Vanuatu deepwater shrimp survey.

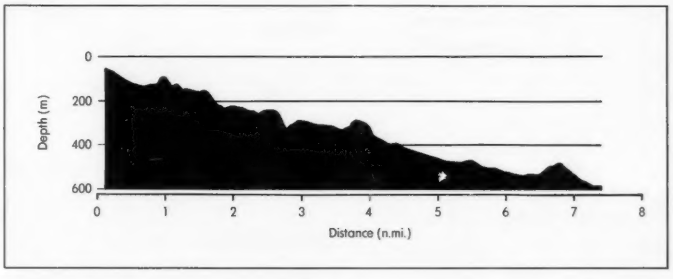



Figure 5.—A depth profile measured by the echo-sounder trace made along the transect indicated in Figure 2.

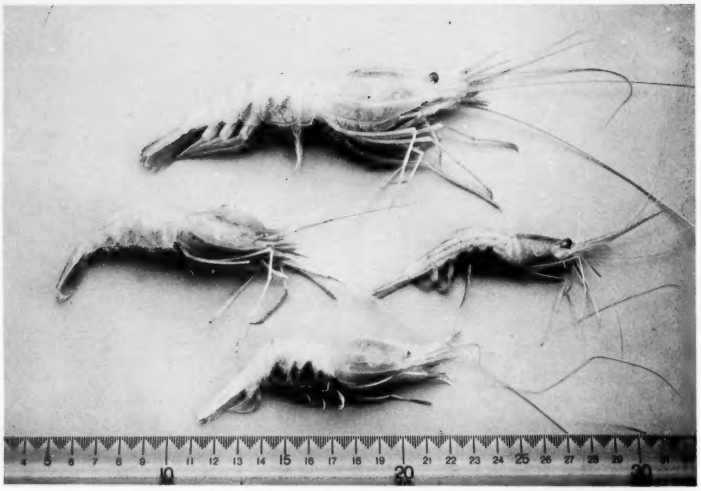
## Results

### Offshore Bathymetry

The echosounder was used to record the depths and sea bottom profiles in several areas offshore from Mélé Bay. The bottom profile along the selected transect shown in Figure 2 is presented in Figure 5, which is drawn from the echosounder recording paper.

### Temperature

Temperatures were recorded on a



Deepwater shrimps, clockwise from top, are *Heterocarpus laevigatus. Plesionika longirostris. H. ensifer.* and *H. gibbosus.*

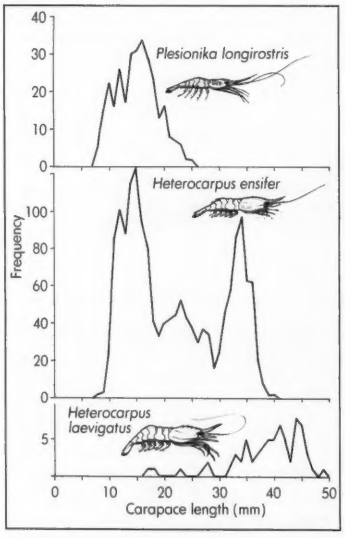



Figure 6.—Length-frequency diagrams of the three most abundant species of deepwater shrimp (samples from all depths combined).

modified maximum/minimum thermometer attached to one of the traps used at each depth. These ranged from 17.5°C at the shallowest depth surveyed (229 m) to 7.5°C at the deepest depth (650 m).

| Depth (m) | Minimum temperature (°C) |
|---|---|
| 229 | 17.5 |
| 384 | 11.0 |
| 454 | 9.5 |
| 650 | 7.5 |

## Species Caught

During the survey, seven species of carid shrimps were provisionally identified from the catch. All belonged to the family Pandalidae and at least three genera: *Heterocarpus, Plesionika,* and *Parapandalus.* In common with other deepwater shrimps, these are characteristically colored pink to deep red and the ovigerious females often carry blue eggs.

The species found are listed in Table 1 in approximate order of increasing size. Scientific names are provisional and common names are from Holthuis (1980) where possible or from King (1980). One species found has not yet been identified and the name of another species, *Heterocarpus ensifer,* is provisional. *Heterocarpus ensifer* is distinguished from *H. sibogae* only by the presence of dorsal carina on the first and second abdominal pleura in the latter species; however, this character appears to be highly variable.

**Table 1.—Provisional list of scientific and common names of deepwater shrimps found in Vanuatu waters. One additional species is, so far, unidentified.**

| Scientific name | Common name |
|---|---|
| *Parapandalus serratifrons* | Pyjama shrimp |
| *Plesionika ensis* | Striped gladiator shrimp[1] |
| *Plesionika longirostris* | Stars and stripes shrimp |
| *Heterocarpus ensifer (sibogae?)* | Armed nylon shrimp |
| *Heterocarpus gibbosus* | Humpback nylon shrimp[1] |
| *Heterocarpus laevigatus* | Smooth nylon shrimp[1] |

[1]Standard FAO name (Holthuis, 1980).

On the basis of this preliminary survey it appears that three of the species found may be present in sufficient quantity to be of commercial interest. These include the two abundant *Heterocarpus* species, *H. ensifer* and *H. laevigatus,* as well as the smaller *Plesionika longirostris.* The length frequencies (from all depths combined) of these three species are shown in Figure 6.

## Catch Analyses

As *Heterocarpus ensifer* occurred over the entire depth range surveyed, it was decided to analyze the catches of this species by both depth and trap type. All catch data were grouped into three depth ranges: Shallow (<350m); middle (350-450m); deep (>450m). After culling suspect data from damaged traps, the mean catch weights were tabulated in a 3×2 matrix of 3 depth ranges and 2 trap types.

An analysis of the variance in the data presented in Table 2 is shown in Table 3. There was no significant difference in the mean catch rates of *H. ensifer* between covered and uncovered traps ($F$=0.01, $P$>0.05) but catch rates varied significantly with depth ($F$= 22.50, $P$<0.05).

## Depth Distribution

Analyses presented in the previous section indicated that the catch weight of *H. ensifer* varied significantly with depth. Using all catch data from the survey, the contribution of various shrimp species to the total catch at each depth was calculated. These contribu-

**Table 2.—Mean catch (kg) per trap of *Heterocarpus ensifer* and variance for each trap type at each of 3 depth ranges.**

| Depth range | Covered | Uncovered | Row means |
|---|---|---|---|
| Shallow (<350 m) | $\bar{X}$ =0.06<br>$S^2$ =0.05 | 0.04<br>0.04 | 0.05 |
| Middle (350-450 m) | $\bar{X}$ =0.95<br>$S^2$ =0.89 | 1.23<br>0.26 | 1.09 |
| Deep (>450 m) | $\bar{X}$ =1.50<br>$S^2$ =0.67 | 1.20<br>0.16 | 1.35 |
| Column means | 0.84 | 0.82 | |

**Table 3.—A two-way analysis of variance in catches (kg/trap) of *H. ensifer* by trap type and depth range.**

| Source | df | S.S. | F |
|---|---|---|---|
| Columns (traps) | 1 | 2.67 | 0.01 ($P>0.05$) |
| Rows (depths) | 2 | 1.89 | 22.50 ($P<0.05$) |
| Error | 2 | 0.08 | |

**Table 4.—Species composition by weight expressed as a percentage of the total shrimp catch in each depth.**

| Depth (m) | *P. longirostris* | *H. ensifer* | *H. laevigatus* | Other species |
|---|---|---|---|---|
| 229 | 15 | 54 | | 31 |
| 262 | 51 | 48 | | 1 |
| 324 | 47 | 49 | | 4 |
| 384 | 27 | 73 | | 0 |
| 421 | <1 | 99 | | <1 |
| 436 | <1 | 99 | | <1 |
| 454 | 2 | 98 | | 0 |
| 461 | <1 | 99 | | <1 |
| 560 | | 57 | 43 | 0 |
| 650 | | 68 | 32 | 0 |

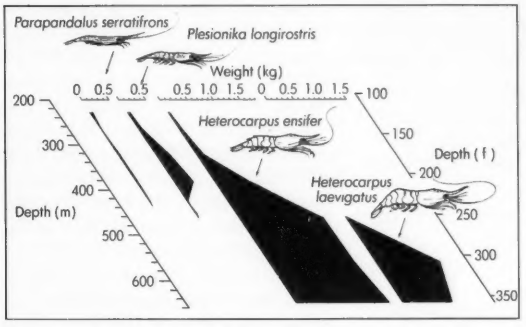



Figure 7.—The depth distribution (mean catch per trap) of the four most abundant deepwater shrimp caught during the trapping survey.

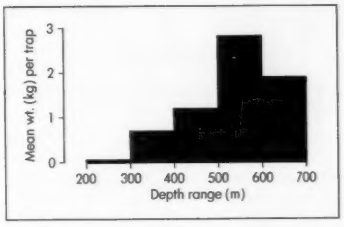



Figure 8.—Mean catch per trap (kg) per 100 m depth.

tions expressed as percentages are given in Table 4.

Species such as *Parapandalus serratifrons* and *Plesionika ensis* which occurred in low trap abundance are grouped together as "other species." *Plesionika longirostris* accounted for up to about half the shallow water catch. *Heterocarpus ensifer* occurred throughout the whole sampled depth range and, from about 400 to 500 m, the catches consisted almost exclusively of this species. In the deepest depths sampled the proportion of *H. laevigatus* in the catch increased with a corresponding decrease in the proportion of *H. ensifer.*

Other species of shrimp usually accounted for <5 percent of the total catch in any depth. An exception was in the shallowest depth sampled (229 m) where the small shrimp *Parapandalus serratifrons* accounted for 31 percent of the small catch.

The distribution of each species of shrimp by depth was estimated by using the mean catch weight per trap as an index of relative abundance. Indices for the four major species are shown in Figure 7. These data are from a limited geographical area and collected over a short time scale; the figure may therefore not represent the general distribution throughout Vanuatu or over a complete seasonal cycle.

## Catch by Depth

The catch data were also examined to determine how the total biomass of shrimp caught relates to depth. These data were grouped in 100 m depth ranges and are presented as a histogram in Figure 8.

The histogram indicates that total mean catches were low in shallower water but increased with depth to a maximum in 500-600 m. At this depth range the mean catch rate was 2.83 kg per trap. Beyond 600 m, trap abundance of shrimp appears to decrease. Taking into account the limited nature of the present survey, however, further research is necessary to discover how shrimp abundance alters in depths >600 m.

## Size by Depth

Length-frequency data were examined to determine whether the size of shrimp changed with depth. *Heterocarpus ensifer* was the only species caught in all of the depth samples; length-frequency data from selected depths are shown in Figure 9. This shows that shrimp size differed markedly with depth, with a greater proportion of large shrimp in the middle part (421-461 m) of the depth range sampled.

Although the total length-frequency diagram (samples from all depths combined) presented in Figure 6 show possibly 3 major size classes (i.e., at modal lengths of 14, 23, and 33 mm) for *H. ensifer,* Figure 9 shows that the proportion of the shrimp in each size class differs with depth. Samples from shallower water (e.g., 324 m) consisted al-

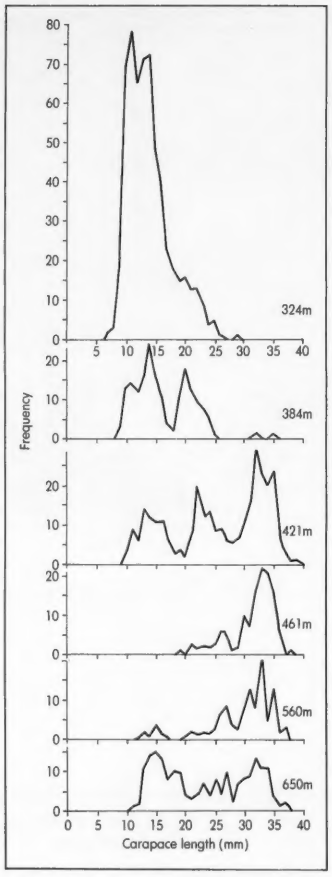



Figure 9.—Length frequency of samples of *H. ensifer* from selected depths. The depth is indicated at the right of each graph.

most entirely of small shrimp from the first and second size class. In middle range depths (e.g., 461 m) shrimp in the smaller size classes were not abundant but appeared again in samples from deeper water.

Surveys carried out in Hawaii (Struhsaker and Aasted, 1974) also indicated that smaller *H. ensifer* are found above and below the depth of maximum abundance.

### Sexuality

As *H. ensifer* was obtained over a large size range (8-40 mm carapace length) it was possible to determine the proportion of ovigerous (egg bearing) individuals in each size class for this species. Figure 10 combines data from all depths ($n$=1,846) and shows the number of ovigerous individuals, expressed as a percentage of the total number, in each size class. At about 30 mm carapace length, half the population consists of ovigerous females; at >35 mm, the population consists entirely of ovigerous females. Both *H. ensifer* and *H. laevigatus* may be protandrous hermaphrodites, existing initially as small males before changing sex to become females.

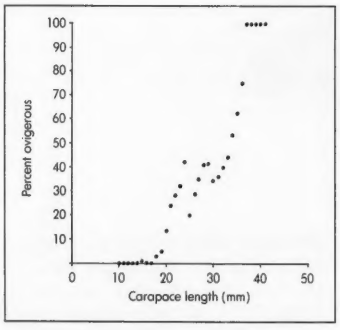



Figure 10.—The percentage of ovigerous females in each size class (data from samples taken at all depths combined: $n$=1,846.

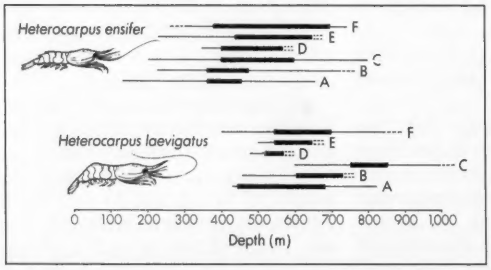



Figure 11.—The depth distribution (light line) and depth of greatest abundance (heavy line) of *H. ensifer* and *H. laevigatus*. References are: A) Hawaii (Struhsaker and Aasted, 1974); B) Guam (Wilder, 1977); C) New Caledonia (Intès, 1978); D) Fiji (Brown and King, 1979); E) this paper; and F) Western Samoa (King, 1980). Dotted lines indicate the limits of the respective surveys.

## Discussion

At least six of the seven species of pandalid shrimps found in the Vanuatu survey have been obtained in other Pacific countries including Fiji (Brown and King, 1979), New Caledonia (Intès, 1978), Guam (Wilder, 1977), Hawaii (Struhsaker and Aasted, 1974), and Western Samoa (King, 1980). Although much of this literature makes no reference to the smaller shrimp, there is some information on the larger *Heterocarpus* species. The depth distribution of *H. ensifer* and *H. laevigatus* in these countries is shown in Figure 11. *Heterocarpus gibbosus,* which accounts for a substantial proportion of the catches in Fiji (at about the 400-500 m depth) was only found in very small numbers in the Vanuatu survey.

Taking into account the limitations of this preliminary survey, the catches of shrimp obtained were sufficient to encourage a further examination of the fisheries potential. In deciding on a fishing strategy, it is not only necessary to consider catch weight but also the size of individual shrimps. In *H. ensifer,* for example, the highest proportion of larger individuals (from the third size class, Fig. 9) was found in depths of about 450-550 m. Although catch weight was still high in depths greater than this, a large proportion of the deeper catch consisted of smaller shrimp (first and second size classes). Trapping in depths of about 550 m appears ideal in that reasonable weights of larger individuals of *H. ensifer* (>1.5 kg per trap) as well as *H. laevigatus* (>1.0 kg per trap) were obtained. The greatest weights of shrimp (all species combined) obtained during the survey was in the 500-600 m

depth range where the mean catch rate was 2.83 kg per trap.

*Plesionika longirostris,* although smaller than *Heterocarpus* spp., is worth some consideration from a commercial point of view. This species has a higher "recovery rate" (the weight of high-value tail meat expressed as a percentage of total weight) than the other species; it is also obtained in shallower water (about 350-400 m) where fishing costs are obviously less than in deeper water. During this survey, however, catches of *P. longirostris* were always <0.5 kg per trap. Further work is needed to determine the trap abundance and depth distribution of this species in Vanuatu.

The economics of any proposed shrimp trapping fishery should be carefully examined. It would be desirable to use small locally made fishing craft. The 8.5 m catamaran used in the preliminary survey was suitable for setting traps because of its deck space and high initial stability. However, such a boat may not be able to carry the total number of traps needed for a commercial operation. Due to the close proximity of the fishing grounds, it may be possible to relay smaller numbers of traps (e.g., strings of 15 traps at a time) out to the drop locations. The development of collapsible traps would also help in this respect.

In Fiji, when traps were sometimes left set longer than for the usual 18-hour (overnight) period there was considerable cannibalism. Results from a series of 24-hour stations suggest that *H. ensifer* and *H. laevigatus,* in spite of their depth of distribution, only enter traps during the night (footnote 2). Cannibalism was not evident in traps set overnight in my Vanuatu study.

Other than the fishing boat itself, there are several other expensive items of fishing equipment required including rope, an echo-sounder capable of detecting the depths involved, and a mechanical or hydraulic pot-hauling winch. It would be possible to use shore bearings in place of the echo sounder to determine fishing locations and depths but this method would depend on the availability of charts with accurate soundings; the method would be less reliable where the sea bottom profile is as undulating as that found during this survey (Fig. 5).

Any examination of the costs involved should include special reference to the increase of costs with fishing depth and the likely incidence of trap loss due to heavy weather, shark attack, etc. During the present survey two traps were damaged, presumably by sharks. One set of traps was lost during the survey, possibly due to an incorrectly tied knot at the float buoy. The cost of bait may also be considerable, although sardines, *Sardinella* spp., were caught by cast-net and successfully used as bait in this survey.

From experiences in Fiji it has been found that the handling of deepwater shrimp requires considerable care—more so, for example, than finfish. Immediately after being caught, shrimp must be placed in crushed ice or chilled brine, and sodium metabisulphite may be used as a dipping solution to extend the cold storage life of the shrimp. Cooking time for deepwater shrimp must be kept short; approximately 2 minutes in boiling water, usually suffices.

In conclusion, it has been established that deepwater carid shrimps are present in Vanuatu waters. Catch rates made during the preliminary survey off Port Vila were high enough to consider carrying out commercial trials. Further work would be necessary to elucidate several points regarding the biological, economic, handling, and marketing aspects of any proposed fishery.


### Acknowledgments

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### Literature Cited


Barr, L. 1970. Alaska's fishery resources: The shrimps. Fish. Res. Board. Can., Fish. Leafl. 631, 10 p.

Brown, I. W., and M. G. King. 1979. Deepwater shrimp trapping project: Report on Phase 1. Fish. Div. Fiji, Tech. Rep. 1, 30 p.

Chart No. 4787 (1893). Ile Éfaté, Archipel des Nouvelles - Hebrides. Service Hydrographique de la Marine, Paris.

Dahlstrom, W. A. 1970. Synopsis of biological data on the ocean shrimp *Pandalus jordani* Rathbun, 1902. *In* M. N. Mistakidis (editor), Proc. World Sci. Conf. Biol. Culture of shrimps and prawns: Mexico City. FAO Fish Rep. 57(4):1377-1416.

Hancock, D. A., and G. Henriquez. 1968. Stock assessment in the shrimp (*Heterocarpus reedi*) fishery of Chile. *In* M. N. Mistakidis (editor), Proc, World Sci. Conf. Biol. Culture of shrimps and prawns: Mexico City. FAO Fish Rep. 57(2):443-465.

Holthuis, L. B. 1980. FAO species catalogue. Vol. 1. Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. FAO Fish. Synop. (125) Vol. 1, 261 p.

Intès, A. 1978. Pêche profonde aux casiers en Nouvelle-Calédonie et iles adjacentes: Essais préliminaires O.R.S.T.O.M. (Noumea) Rapports Scient. et Tech. 2, 10 p.

King, M. G. 1980. A trapping survey for deepwater shrimp (Decapoda: natantia) in Western Samoa. Rep. Inst. Mar. Resour., Univ. South Pacific, Fiji, 26 p.

Pacific Islands Pilot, Volume II. 1969. Ninth edition. Hydrographic Department, Royal Navy, United Kingdom.

Struhsaker, P., and D. C. Aasted. 1974. Deepwater shrimp trapping in the Hawaiian Islands. Mar. Fish. Rev. 36(10):24-30.

Wilder, M. J. 1977. Biological aspects and fisheries potential of two deepwater shrimps, *Heterocarpus ensifer* and *H. laevigatus,* in waters surrounding Guam. Master's Thesis, Univ. of Guam, 79 p.

# Frozen Storage Stability of Whole and Headless Freshwater Prawns, *Macrobrachium rosenbergii*

MALCOLM B. HALE and MELVIN E. WATERS

*ABSTRACT—The freshwater prawn,* Macrobrachium rosenbergii, *is being increasingly cultured in tropical regions and has aquacultural potential in temperate zones. Very little information on frozen storage stability has been published, however. In this study, frozen glazed prawns were stored whole (both raw and precooked) and deheaded (raw) for 9 months at −20°C. Chemical, physical, microbiological, and sensory evaluations were made at intervals during storage. All samples had a firmer texture after 3 months of frozen storage but the samples stored and cooked whole had a consistently softer texture than those stored as tails. This was due more to the prawns being boiled whole than to changes during frozen storage. An increase in total volatile nitrogen between 6 and 9 months was not reflected in other measurements, but there was a general decline in acceptability over the course of the study.*

## Introduction

The culture of freshwater prawns, *Macrobrachium rosenbergii,* in temperate zones is potentially profitable (Roberts and Bauer, 1978; Liao and Smith, 1980). The prawns must be seasonally batch harvested, however, before water temperatures become lethal (Brody et al., 1980); thus, most of the prawns must be frozen for later marketing. Commercial operations in more tropical areas, such as Hawaii, selectively harvest larger prawns from year-round culture ponds for marketing as a fresh product, primarily to the restaurant trade. Recently, rapidly increasing production has stimulated interest in the marketing of frozen products (Reddy et al., 1981).

Little information is available on the frozen storage stability of freshwater prawns. Miyajima and Cobb (1977) reported their preliminary observations on prawns frozen and stored both whole and headed and either glazed or vacuum packaged. They measured nitrogenous compounds (ammonia, trimethylamine, and total volatile nitrogen) and bacterial counts. A significant decrease in organoleptic quality of heads-on prawns was noted after more than 6 months of storage, but this was not indicated by their chemical or microbiological test results. Nip and Moy (1979) evaluated prawns that had been frozen by several different methods and stored for 1 month at −15°C. Textural changes were noted but there were no significant losses in sensory quality due to frozen storage.

This study was conducted in cooperation with personnel of the South Carolina Marine Resources Research Institute (MRRI), who have been developing culturing methods for prawns for several years. Our objectives were to evaluate the frozen storage stability of headed prawns and whole prawns which could be marketed as a gourmet restaurant product, as in Hawaii.

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## Materials and Methods

The *Macrobrachium* prawns used in this study were provided by MRRI personnel from the October 1979 harvest of experimental culture ponds. The freshly harvested prawns were immersed in ice water and transported to the Marine Resources Center where they were graded. Large prawns weighing about 50 g (9/pound) were selected for storage whole and medium prawns weighing about 25 g (18/pound) were selected for storage as tails.

Three experimental packs were prepared: 1) Raw tails, 2) raw whole prawns, and 3) prawns that were boiled, frozen, and stored whole (precooked). The prawns were layered on trays and rapidly frozen in a Hobart[1] blast freezer to an internal temperature of −34°C. The frozen prawns were glazed by being dipped twice into ice water before they were packaged in 5-pound waxed paperboard cartons and stored at −20°C. A reference standard sample was prepared, consisting of raw frozen tails (18 count). The tails were glazed, packed in waxed cartons, wrapped with PVC film, sealed in freezer bags, and stored at −40°C. Sufficient samples were prepared for evaluation at zero time and 1, 3, 6, and 9 months. The evaluations included organoleptic ratings of appearance, flavor, texture, and overall acceptability plus mechanical shear values, total volatile nitrogen (TVN), pH, and microbiological analyses.

### Sensory Evaluation

Sensory evaluations were made by a trained taste panel consisting of 12 laboratory personnel. All tests were made with the cold, boiled product. Experimentally stored tails, and the reference standard, were thawed, peeled, and deveined, cooked in boiling 2 percent saltwater for 2 minutes and rinsed with cold water. The whole, raw stored samples

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

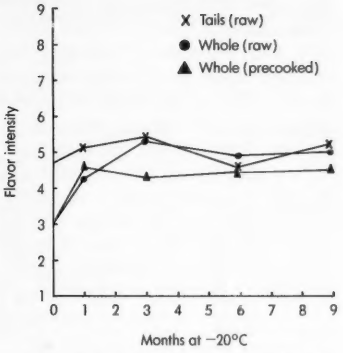


Figure 1.—Average flavor intensity of frozen prawns as perceived by taste panel (scale of 1 to 9, standard reference = 5.0).

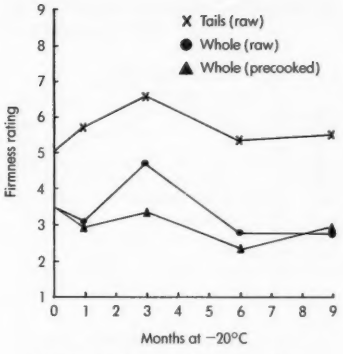


Figure 2.—Texture (firmness) of frozen stored prawns relative to standard reference sample at 5.0.

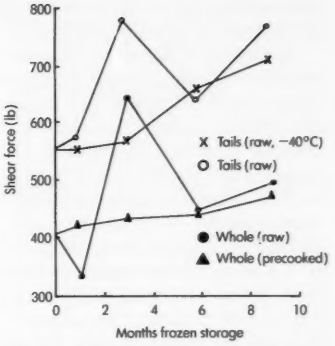


Figure 3.—Average mechanical shear values for experimental and standard reference samples.

were cooked in boiling 3 percent saltwater for 3 minutes, rinsed, deheaded, peeled, and deveined. The third set of samples, precooked whole as above prior to frozen storage, were thawed, headed, peeled, and deveined. All samples were refrigerated for at least 2 hours between cooking and sensory evaluation.

The taste panelists rated the samples for appearance, flavor, and texture relative to the reference standard sample. A 9-point rating scale was used in which the fifth, or center point, was labeled as equal to the standard. The overall acceptability was rated on a 9-point hedonic scale without reference to the standard. Ratings ranged from "like extremely" at 9 through "neutral" at 5 to "dislike extremely" at 1.

### Physical Analyses

The texture of the prawns was evaluated mechanically by use of a Kramer shear press. Peak heights of force curves were measured for triplicate 100 g samples of cooked, chilled tail meat.

### Chemical Analyses

Total volatile nitrogen (TVN) analyses were conducted using the modified Conway microdiffusion technique described by Obrink (1955) and further modified by Cobb et al. (1973). The pH was measured by direct contact of a combination pH electrode with the thawed, macerated flesh.

### Microbial Analyses

The total aerobic plate count (TAPC), most probable number (MPN) of coliform bacteria and *Escherichia coli,* and the presence or absence of salmonella were determined according to FDA's Bacteriological Analytical Manual for Foods (AOAC, 1976). Standard plate count agar was used as the plating medium for the TAPC. Plates were incubated at two different temperatures: 35°C for 48 hours and 22°C for 5 days. Suspect salmonella cultures were subjected to serological testing for identification. The TAPC is reported as per gram of sample, coliforms and *E. coli* as MPN per 100 g of sample, and salmonella as presence or absence of the organism. Reported results are the average of three replicates.

## Results and Discussion

### Flavor and Appearance

Sensory evaluations of flavor and appearance showed no definite trends over the 9-month period of frozen storage. The taste panel evaluations of flavor intensity are shown in Figure 1. The test scale ranged from 1 (much milder) to 9 (much stronger) with 5 being equal in flavor to the reference standard sample stored at −40°C. Moderate increases in flavor intensity over the first 3 months of storage leveled out over the remainder of the study.

### Texture

The taste panel evaluations of texture are shown in Figure 2. The raw samples increased in firmness (relative to the standard) during the first 3 months of frozen storage. After 9 months the whole prawns were slightly softer and the tails slightly firmer than initial values (relative to the standard). The softer texture of the whole raw and precooked samples was due primarily to the fact that they were cooked whole, in contact with the enzymes of the hepatopancreas, while the raw tails and standard reference samples were boiled as peeled tails. This is indicated by the texture difference (Fig. 2) between the tails and whole prawns at the beginning of the storage study. The shear values for replicate 100 g samples, as measured with the mechanical shear press, are shown in Figure 3. The pattern is similar to that perceived by the taste panel but shows a more pronounced increase in firmness for the raw experimental samples at 3 months. The standard reference sample showed a moderate but steady increase in shear value. The precooked sample had a very slight increase in firmness over the 9-month frozen storage period.

This stability may be attributed to a partial destruction of enzymes by cooking.

The increased firmness of the *Macrobrachium* with storage was not expected. Webb et al. (1975), however, reported that brown shrimp, *Penaeus aztecus,* showed increased mechanical shear values after storage for 60 days at −20°C. Hose and Lightner (1980) reported that the tail muscle of cultured *P. stylirostris* produced small amounts (up to 4.8 ppm) of formaldehyde during postmortem decomposition. Trimethylamine oxide (TMAO) is the precursor of formaldehyde (which causes toughening of the flesh) and dimethylamine (DMA) in gadoid fish species. No TMA was detected in our analyses of fresh or stored *Macrobrachium,* however.

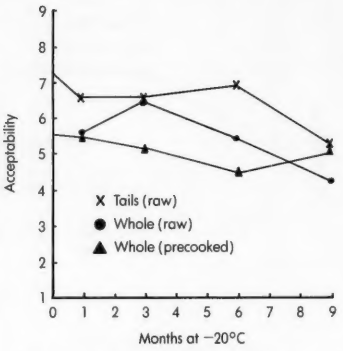


Figure 4.—Acceptability of frozen stored prawns as judged by taste panel (9 point hedonic scale).

**Table 1.—Total volatile nitrogen (TVN, mg N/100g), total aerobic plate count (TAPC), and pH of frozen *Macrobrachium* prawns.**

| Storage period | Sample[1] code | TVN | TAPC/g @22°C | TAPC/g @35°C | pH |
|---|---|---|---|---|---|
| 0 | T-R | [2]8.16 | $78X10^4$ | $64X10^4$ | 6.30 |
| 1 month | T-R-20 | 12.87 | $55X10^4$ | $55X10^4$ | 6.60 |
| | T-R-40 | 14.40 | — | — | 6.70 |
| | W-R-20 | 14.29 | — | — | 6.58 |
| | W-C-20 | 10.17 | — | — | 6.60 |
| 3 months | T-R-20 | 13.04 | — | — | 6.60 |
| | T-R-40 | 12.79 | — | — | 6.60 |
| | W-R-20 | 12.60 | — | — | 6.50 |
| | W-C-20 | 11.78 | — | — | 6.90 |
| 6 months | T-R-20 | 10.03 | $17X10^4$ | $18X10^4$ | 6.43 |
| | T-R-40 | 10.80 | — | — | 6.45 |
| | W-R-20 | 12.82 | — | — | 6.45 |
| | W-C-20 | 11.85 | — | — | 6.65 |
| 9 months | T-R-20 | 26.22 | $47X10^3$ | $35X10^3$ | 6.28 |
| | T-R-40 | 25.72 | — | — | 6.30 |
| | W-R-20 | 20.09 | — | — | — |
| | W-C-20 | 17.72 | — | — | 6.55 |

[1]T-R-20 = Tails, stored at −20°C; T-R-40 = Tails, −40°C; W-R-20 = Whole, raw, −20°C; W-C-20 = Whole, precooked, −20°C.
[2]the TVN and TAPC values are averages of three replicate analyses each.

## Chemical and Microbiological Tests

The results of analyses for TVN, TAPC, and pH are listed in Table 1. The TVN values remained relatively low for all samples through the first 6 months of storage. The higher values for the final 9-month samples have not been explained and were not reflected in the sensory evaluations. The bacterial plate counts decreased steadily over the frozen storage period. Although not shown, coliform counts dropped from 60/100 g to 9/100 g MPN and neither *E. coli* nor salmonella was detected. The pH values remained relatively stable throughout the storage period.

## Acceptability

The average taste panel judgments on the overall acceptabilities of the experimental products are shown in Figure 4. There was a general downward trend in acceptability and deviations could be related to texture. The whole raw sample tended to be too soft after cooking whole but the increased firmness at 3 months resulted in an increase in acceptability, which was followed by a decline. Conversely, the tails were disagreeably tough at 3 months and the decreased firmness at 6 months corresponded with a slightly higher acceptability.

## Statistical Analysis

The taste panel results required analysis by nonparametric statistics because scoring was limited to nine discrete values. The Friedman two-way analysis of variance (ANOVA) tests indicated that at $\alpha = 0.05$ there were significant differences between sample medians for texture but not for flavor or acceptability. The nonparametric Wilcoxon signed-rank test was applied to pairs of products at each storage time with the results as shown in Table 2. The whole and precooked whole samples were significantly softer than the tails.

The results of the Welch ANOVA tests for equality of product means for TVN and mechanical shear press values are listed in Table 3. The differences in shear press values are highly significant.

**Table 2.—Results of nonparametric Wilcoxon signed-rank tests on each pair of products at each storage time. * indicates rejection of equality of median at the significance level $\alpha = 0.05$.**

| Item | | Month 0 | 1 | 3 | 6 | 9 |
|---|---|---|---|---|---|---|
| Whole vs. precooked | Flavor | | | | | |
| | Texture | | | * | | |
| | Acceptability | | | | | |
| Whole vs. tail | Flavor | | | | | |
| | Texture | | * | * | * | * |
| | Acceptability | | | | | |
| Precooked vs. tail | Flavor | * | | | | |
| | Texture | | * | * | * | * |
| | Acceptability | | | | * | |

**Table 3.—*P* values of the Welch ANOVA tests to test equality of means among product forms for TVN and shear value at each storage time. Equality of means is rejected when $P<0.05$.**

| Month | *P* value TVN | Shear value |
|---|---|---|
| 0 | — | 0.0022 |
| 1 | 0.0394 | 0.0001 |
| 3 | 0.8948 | 0.0004 |
| 6 | 0.1432 | 0.004 |
| 9 | 0.0914 | 0.0075 |

## Conclusions

The *Macrobrachium* prawns that were frozen and stored whole, either raw or precooked, had a significantly softer texture than the samples stored as raw tails. The softness was due primarily to the samples being cooked whole, in contact with digestive enzymes, rather than to changes occurring during storage. This was indicated by the difference between firmness of tails and whole prawns at zero time, which persisted during frozen storage.

Raw samples stored at −20°C devel-

oped peak firmness after 3 months. There was little change in the texture of the precooked prawns but they were very soft from the beginning and were of borderline acceptability. The acceptability of the raw samples declined during storage and if a taste panel rating of 5 is taken as the borderline of acceptability, the storage life is estimated to be about 7 months for whole prawns and about 10 months for tails. The frozen storage life for whole prawns could be greater if other methods for cooking are used.


### Acknowledgments

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### Literature Cited


AOAC. 1976. Bacteriological analytical manual for foods. Assoc. Off. Analytical Chem., Wash., D.C.

Brody, T., D. Cohen, A. Barnes, and A. Spector. 1980. Yield characteristics of the prawn *Macrobrachium rosenbergii* in temperate zone aquaculture. Aquaculture 21:375-385.

Cobb, B. F., I. Alaniz, and C. A. Thompson, Jr. 1973. Biochemical and microbial studies on shrimp: Volatile nitrogen and amino nitrogen analysis. J. Food Sci. 38:431-436.

Hose, J. E., and D. V. Lightner. 1980. Absence of formaldehyde residues in penaeid shrimp exposed to formalin. Aquaculture 21:197-201.

Liao, D. S., and T. I. J. Smith. 1980. The marketing opportunity for freshwater shrimp in South Carolina: A preliminary survey. *In* Proc. 5th Annual Trop. Subtrop. Fish. Technol. Conf., p. 67-69. Texas A&M Univ. Publ. TAMU-SG-81-101.

Miyajima, L. S., and B. F. Cobb. 1977. Preliminary observations on the frozen storage stability of the freshwater prawn, *Macrobrachium rosenbergii.* Proc. 2nd Annual Trop. Subtrop. Fish. Technol. Conf., p. 253-261. Texas A&M Univ. Publ. TAMU-SG-78-101.

Nip, W. K., and J. H. Moy. 1979. Effect of freezing methods on the quality of the prawn, *Macrobrachium rosenbergii.* Proc. World Maricult. Soc. 10:761-768.

Obrink, K. J. 1955. A modified Conway unit for microdiffusion analysis. Biochem. J. 59:134-136.

Reddy, S. K., W. K. Nip, and C. S. Tang. 1981. Changes in fatty acids and sensory quality of freshwater prawn (*Macrobrachium rosenbergii*) stored under frozen conditions. J. Food Sci. 46:353-356.

Roberts, K. J., and L. L. Bauer. 1978. Costs and returns for Macrobrachium grow-out in South Carolina, U.S.A. Aquaculture 15:383-390.

Webb, N. B., A. J. Howell, B. C. Barbour, R. J. Monroe, and D. D. Hamann. 1975. Effect of additives, processing techniques and frozen storage on the texture of shrimp. J. Food Sci. 40:322-326.

## Baldrige Names 19 to Fishery Management Councils

Commerce Secretary Malcolm Baldrige has named 14 new members and reappointed 5 incumbents to the nation's eight regional fishery management councils. The appointments, announced by John V. Byrne, administrator of the National Oceanic and Atmospheric Administration (NOAA), were effective 11 August and will run for 3 years.

The councils, established by the Magnuson Fishery Conservation and Management Act, prepare fishery management plans for stocks of fish found in waters within their geographical areas. The act requires that council members be selected from lists submitted by governors of the constituent states.

The new members appointed are:

New England Council: Edward A. Blackmore, executive director, Maine Lobstermen's Association, Stonington, Maine; Thomas A. Fulham, chairman, Fulham and Maloney, Inc., Boston; and James W. Salisbury, commercial fisherman, Milbridge, Maine.

Mid-Atlantic Council: Robert T. Cooper, fish processor, Robert T. Cooper, Inc., Greenport, N.Y.; and Richard H. Miller, executive secretary, Long Island Fishermen's Association, East Quogue, N.Y.

South Atlantic Council: Belton O. Sanders, III, president Sanders Transport, Inc., Allendale, S.C.; and John Colburn, VP/Marketing, DESCO Marine, St. Augustine, Fla.

Gulf of Mexico Council: Maumus Claverie, Jr., attorney, New Orleans, La.; Julius Collins, president, J. Collins Trawler-Gulf Shrimp Company, Brownsville, Tex.; and Gary Knight, professor of law, Louisiana State University Law Center, Baton Rouge, La.

Pacific Council: James A. Crutchfield, professor, Department of Economics, University of Washington, Seattle; and George J. Easley, administrator, Otter Trawl Commission of Astoria, Oreg.

North Pacific Council: Keith Specking, legislative assistant to the governor, Juneau, Alaska.

Western Pacific Council: Betty S. Guerrero, director, Bureau of Planning, Office of the Governor, Agana, Guam.

Incumbents reappointed are:

Mid-Atlantic Council: Elliot J. Goldman, attorney, the Philadelphian, Philadelphia, Pa., and Ricks E. Savage, commercial fisherman, Berlin, Md.

Caribbean Council: Jose Luis Campos, insurance broker, John Hancock Mutual Life Insurance Co., Hato Rey, Puerto Rico.

North Pacific Council: Harold E. Lokken, retired, Seattle, Wash.

Western Pacific Council: Wadsworth Y. H. Yee, president, Grand Pacific Life Insurance Co., Honolulu, Hawaii.

## *Hawaiian Cruise Eyes Lobster Predation*

Cruise 81-04, the last in a 5-year series of expeditions of the *Townsend Cromwell* to investigate the biological resources of the northwestern Hawaiian Islands (NWHI), ended on 27 August after a 6-week trip. The main objective of the cruise was to continue investigations of such species as spiny lobster, shrimp, kona crab, bottom fish, and pelagic fish around Necker Island, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Pearl and Hermes Reef, Raita Bank, St. Rogatien Bank, and several other small banks in the chain, according to Richard Shomura, Director of the NMFS Southwest Fisheries Center's Honolulu Laboratory.

During lobster trap fishing operations, experiments were also conducted to determine the efficacy of escape panels in traps to release undersized lobsters, and the effect on the catch of the presence of lobster offal in the area of trap sets. The results of the latter experiments showed that lobster remains in the vicinity of traps apparently do have a very detrimental effect on the catch of spiny lobster.

Observations made from commercial lobster fishing vessels and from the *Townsend Cromwell* while hauling lobster pots in NWHI waters also have indicated that there is some predation by large carangids (uluas, *Caranx ignobilis*) and sharks on undersized and berried spiny lobsters when they are returned alive to the sea after being sorted from the catch. Lobsters released at the surface must return to the bottom in depths ranging from 15 to 60 m, thus exposing them to predation in midwater for some time before reaching the relative safety of the bottom.

One of the missions of the cruise was to determine the probability of lobsters safely reaching the bottom when they are released from the surface when potential predators are present, and the vulnerability of lobsters to predation when they are released at the bottom from a specially designed release bag. During the experiments, divers made visual observations and 16 mm movies to document predation on the released lobsters.

Underwater observations during the experiments corroborated the earlier suface observations. Large white uluas are indeed voracious predators on lobsters not only in midwater but when they are released at the bottom. In addition, the underwater observations provided interesting insights into various aspects of the behavior of prey and predator, under the experimental conditions.

Reginald M. Gooding of the NMFS Honolulu Laboratory served as Chief Scientist for the cruise. Other members of the scientific party were George H. Balazs, Steven H. Kramer, James L. Prescott, Michael P. Seki, and Gordon W. Tribble.

# The Tuna Fishery of the Ivory Coast

Except for tuna, the fishing industry of Ivory Coast has suffered from relative stagnation during the 1970's. The country's coast waters are heavily fished. The artisanal fisheries catch has remained stable at approximately 25,000 metric tons (t) over much of the decade. The commercial catch has also been stable, with an average annual trawl catch of about 16,000 t and an annual catch by sardine seiners of about 29,000 tons.

The only consistently expanding sector of the Ivory Coast's fishing industry has been the tuna fishery, which, despite a slight drop in 1978, has increased almost sevenfold since 1971. Not including tuna, the total annual fisheries catch of Ivory Coast has risen by only 1,200 t since 1975, from 62,000 t to 63,200 t, for an increase of less than 2 percent. When tuna is included in those figures, the industry grew by 15 percent, from 68,500 t in 1975 to 79,000 t in 1978.

## Catch

Tuna fishing only began in Ivory Coast during 1971 when fishermen caught 2,000 t (Table 1). Over the course of the decade the catch had increased to 15,800 t by 1978. The biggest increase came during the 4-year period from 1973 to 1977, when the tuna catch rose by about 380 percent from 3,500 t to 16,800 t due to the addition of several new vessels to the fleet. Tuna made up nearly 75 percent of the increase in the total fisheries catch over the same period of time. No data is available for 1979 and 1980, but French and Spanish fishermen reported poor catches in 1979 off Ivory Coast. Catches in 1980 have reportedly been much better.

## Species

The three main species of tuna caught by Ivorian fishermen are yellowfin, skipjack, and little tuna. Yellowfin tuna has consistently been the most important species caught, and catches have risen eightfold since 1971. Skipjack tuna catches have risen throughout the 1970's, but not as dramatically as yellowfin tuna; in addition, unlike yellowfin tuna, skipjack tuna catches fell in 1978, by 700 t. Little tuna, first caught in 1974, has fallen sharply since that year, and in 1978 reached a low of only 38 t (Table 1).

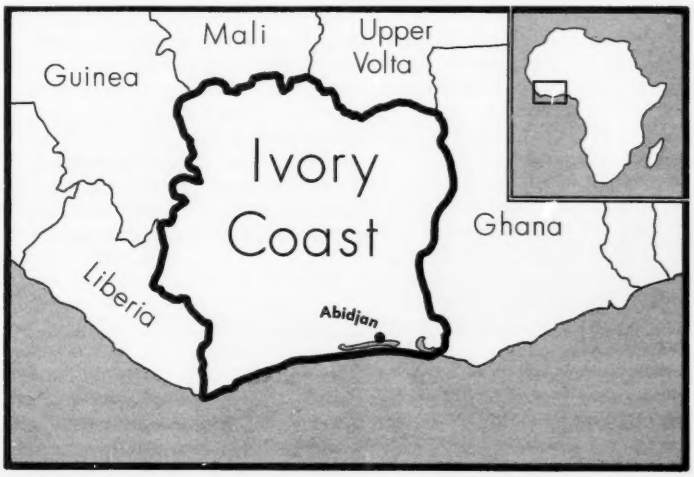
## Fleet

The Ivory Coast tuna fleet, while small, is the most modern of any African country and one of the most modern in the world. It consists of nine purse seiners with an average age of 6 years, all French-built and outfitted with onboard freezing equipment. The newest addition to the fleet, a 69 m purse seiner with a helicopter pad, was also constructed by a French shipyard. It is the sixth tuna vessel ordered by the Ivory Coast-French joint venture SIPAR (Societe Ivoirienne de Peche et d'Armement), of which the Ivory Coast Government is the majority shareholder. It was followed later in 1980 by another vessel of the same type constructed for SMGL (Scieries moderns de Grand Lahou), which had two tuna vessels. The ninth vessel in the Ivory Coast tuna fleet is operated by SCODI (Societe des Con-

Table 1.—The Ivory Coast catch of tuna and tuna-like species, 1971-78[1].

| | Catch (t) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 |
| Yellowfin | 1,200 | 2,200 | 2,500 | 3,015 | 4,83 | 7,420 | 10,026 | 10,138 |
| Skipjack | 800 | 1,200 | 1,000 | 2,350 | 3,500 | 3,110 | 6,327 | 5,602 |
| Little tuna | — | 0 | 0 | 1,583 | 860 | 400 | 413 | 38 |
| Total | 2,000 | 3,400 | 3,500 | 6,948 | 9,190 | 10,930 | 16,784 | 15,778 |

[1]Source: FAO "Yearbook of Fishery Statistics, 1978," and preliminary 1978 data.



serves de Cote d'Ivoire), a catching and processing company.

All nine vessels in the tuna fleet are members of the French tuna fishing company, SOVETCO (Societe de Vente de Thon Congele). SOVETCO operates the Ivory Coast vessels in addition to 26 French and 3 Moroccan tuna vessels. The vessels are based in Abidjan, where most of their catch is landed or transshipped. Most of the rest is landed at Dakar, Senegal. SOVETCO markets the tuna for the Ivory Coast vessel owners, either selling it to Ivory Coast processing plants for transshipping it through Abidjan.

### Processing

There are two canneries in Ivory Coast. One is operated by SCODI, the other by PFCI (Peche et Froid de Cote d'Ivoire). Both of these plants are located in Abidjan, within a few hundred meters of the fishing port facilities. The SCODI plant has a capacity of 16,000 t (live weight) per year and PFCI can process approximately 8,000 to 10,000 t per year. Almost all of the canned tuna produced by these plants is exported. The offal from the canneries is used locally for animal feed.

### Fisheries Trade

Exports of Ivory Coast fishery products increased fivefold from 1970 to 1975, from $2.6 million to $13 million, and more than doubled from 1975 to 1978, reaching $26 million in 1978. Tuna had, by 1978, become the most important Ivory Coast fishery export commodity. Earlier, in the 1970's, tuna and shrimp were equally important, but tuna exports have since come to dwarf shrimp exports. Although the prices of both products rose over the 1970's, the total shrimp catch remained stable at approximately 1,100 t, while the tuna catch expanded dramatically. By 1978 tuna had come to totally dominate Ivory Coast fishery exports. Of the 16,800 t of fishery products exported in 1978, about 15,900 t (live weight) was tuna. Of the tuna, 2,600 t was exported frozen and 13,300 t was exported canned (Table 2). About 90 percent of the canned tuna exports go to France, and the rest goes to other European countries. The exports of frozen tuna are split fairly evenly between France, Italy, and the United States. United States imports of frozen tuna from Ivory Coast were, according to U.S. import data, 7,800 t in 1978, but declined to only 2,300 t in 1979. These figures do not agree with Ivory Coast export data. It is possible that the U.S. import statistics include tuna caught by non-Ivory Coast fishermen and landed in Abidjan for transshipment to the United States.

Exports of tuna are important to the Ivory Coast economy because they help offset the country's imports of cheaper frozen fish. The total annual fisheries catch of Ivory Coast satisfies only about one-half of the total demand for fish, and the rest must be supplied by imported fish. The value of these imports skyrocketed between 1970 and 1975, rising from only about $3.5 million to $33 million over that period. Since 1975, imports have peaked, rising by only $2 million between 1975 and 1978 to a total of $35 million. Adjusted for inflation, this total indicates that the level of imports has actually declined over that period. Much of the imports are obtained from Soviet stern factory trawlers which operate off the coast of western and southern Africa.

**Table 2.—Quantity (t) and value (US$1,000) of Ivory Coast exports of fishery products and canned tuna, 1976-78[1].**

| | All fish | | Canned tuna | |
|---|---|---|---|---|
| Year | Quantity | Value | Quantity[2] | Value |
| 1976 | 14,238 | 19,259 | 12,589 | N/A |
| 1977 | 17,193 | 24,341 | 15,860 | N/A |
| 1978 | 16,766 | 29,977 | 13,231 | 24,377 |

[1]Source: *Bulletin de l'Afrique noire*, 2 July 1980. The data varies from export data reported by FAO but is used as it was the most recent available.
[2]Live weight equivalent.

### Transshipment

The port of Abidjan is the most important transshipment center for tuna in Africa, and is among the most important in the world. Large cold stores and ship repair and maintenance facilities combine with a stable political situation and good weather to make Abidjan attractive to foreign fishermen. In 1975, about 76,000 t of tuna were landed in or transshipped through Abidjan. By 1978, the figure had risen to almost 100,000 t. Of that total, about 16,000 t were landed, and the other 84,000 t were transshipped. Ivory Coast officials estimate that tuna vessels make about 500 port calls annually in Abidjan. The largest fleet is that of SOVETCO, which transshipped over 40,000 t in 1978 in additon to the 16,400 t it landed in Abidjan[1]. The Spanish fleet transshipped about 16,000 t through Abidjan in 1978. The remaining 28,000 t of transshipped tuna came from Korean (ROK), Taiwanese, Japanese, U.S., Senegalese, and other French vessels.

### Conclusion

The Government of Ivory Coast would like to promote the continued expansion of the country's tuna industry. At least two more tuna purse seiners have been ordered, and industry sources have stated that the new vessels would enable Ivory Coast fishermen to catch 25,000 t of tuna this year. This expansion is necessary if Ivory Coast is ever to completely cover the cost of its imported fish. Expansion of other sectors of the fishing industry is unlikely. The fishery resources of Ivory Coast waters are already heavily exploited by both domestic and foreign fishermen. Attempts to expand the activities of the commercial fleet in the waters of other African countries is becoming more difficult as these countries try to expand the activities of their own domestic fleets. (Source: IFR-80-179.)

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Biweekly (LSB) reports produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

[1]Most of the tuna landed is the catch of the Ivory Coast vessels, but small amounts from the other vessels managed by SOVETCO are also landed for processing in local canneries.

## FISHERIES AND FISH CULTURE IN ISRAEL

In 1979 the total production of Israeli fisheries increased by 398 t (2 percent) from 1978. This is the largest catch for the last 5 years, higher by 7.5, 0.9, 3.7, and 1.6 percent as compared with 1975, 1976, 1977, and 1978, respectively.

The main growth in catch was that of the pelagic fisheries (33 percent), Lake Kinneret (26 percent), and the Atlantic deep-sea fisheries (13 percent). There was a slight decline in the yields of the inshore fisheries (1 percent), trawl fisheries (8 percent), and fish ponds (5 percent). There was a fairly large drop in the quantity of pond fish marketed: 663 t (5 percent) compared with 1978. This was not due to any scarcity of fish source but rather to a lower demand for marketed pondfish species.

The per capita consumption rose from 10.3 kg in 1978 to 10.5 kg in 1979. Because the supply of fish from local sources increased only slightly, the additional demand was met by a greatly enlarged supply of imported fish: 3,163 t more than in 1978. The proportion of imported fish in the total consumption was more than 43 percent. The trend to increase imports was already evident as far back as 1975 when the ratio was 29 percent. In 1979, canned and processed fish composed almost 32 percent of the total consumption. The pondfish contribution to the total per-capita consumption dropped to 31.4 percent from 39 percent in 1978.

### Marine Fisheries

The 1979 total marine catch rose by 612 t (7 percent) in comparison with 1978, though there were wide differences in the hauls of the various sources. The trawl fishery suffered a decrease of 8.5 percent (89 t) and the inshore fisheries, one of 8 percent (147 t). On the other hand, there was a marked rise in the haul of the pelagic fisheries (188 t or 33 percent) and in the deep-sea catch of the Atlantic (660 t or 12.6 percent), which together more than compensated for that of the other sources. Slightly more than 1,400 t of the total Atlantic deep-sea catch of nearly 6,000 t were sold abroad.

### Fish Culture

As in the previous 2 years, the economic conditions of the fish industry continued to be critical, complicated, and frustrating for the producers. This was due to two contradictory trends. It is true that continuing advances in research, professional skill, and technology have brought about further increases in yield per unit of area. At the same time, however, the market demand for pond fish, especially common carp, has continued to drop and the cost of production, in particular the higher energy cost and water, has increased. As a result, the profitability of the fish culture industry has been severely affected and several farms (mainly small ones) have utilized their water for more profitable growth and closed down altogether.

Several farms have overcome the economic obstacles by revamping the ponds for use as irrigation reservoirs and integrating them into general farms water scheme. The water is used not only for growth of fish but also for irrigation, especially of surrounding cotton fields.

This year's yields show increased divergencies in the various farm productivity groups. The number of farms with low yields increased due to: low water supplies because of the 1979 drought; the drying-out of ponds in many farms for adaptation as large reservoirs for the integrated system; and because of the ponds in the process of liquidation.

Because of lack of statistical data relating to the pond area in 1978, it is only possible to compare 1979's results with those of 1977. The number of farms in 1979 remained 77 as in the previous year. However, two farms closed down during the year and were counterbalanced by two new farms joining the industry by adjusting their irrigation reservoirs to fish culture.

The total pond area (not including experimental stations, trout farms, and one large reservoir of 500 ha) dropped to 3,530 ha, i.e., 624 ha (5 percent) less than in 1977, and 27 percent less than in 1971, the year of maximum fish pond area. The total quantity of marketed fish decreased due to reasons mentioned above, to 12,322 t, i.e., 795 t (6 percent) less than in 1978 and 1,132 t (8 percent) less than in 1977, the peak year for marketed pondfish.

The national average yield per ha increased by 7.8 percent from 1977 and reached 3,491 kg/ha, rising in spite of the 1979 drought and water shortage.

In reviewing the results of 1979, it is evident that the fish farming industry possesses a large and unutilized potential which could be harnessed if there were a market to absorb the production. In the meantime, there is a certain stagnation in the industry's development. (Source: LSB 81-12.)

## Norway Eyes Seaweed Cultivation Prospects

The cultivation of seaweed and sea wrack can form the basis for a Norwegian industry with a range of products including gas, coal, concentrated cattle foods, food for human consumption, and a wide spectrum of chemical products, according to the Norwegian Information Service. Information on the possibilities for better utilization of seaweed is given in a report from the Foundation for Scientific and Industrial Research (SINTEF) in Trondheim. The report concludes that it would be advisable for Norway to grant resources for research and development into the exploitation of marine algae. The research workers behind the report point out that Norway has Europe's biggest resources of seaweed and sea wrack, an extensive and productive coastal area, very limited possibilities for agriculture along the coast, and long traditions within research into algae.

Seaweed is to some extent already being utilized in the production of seaweed flour and alginates which are used as thinning agents in, for example, the foodstuffs and textiles industry. Norway has 50 percent of the total world production of seaweed flour and 20 percent of alginate production. Nevertheless, this constitutes only a very modest utilization of the available resources. The report states that the reserves of seaweed are enough to provide a tenfold increase in the production of seaweed flour, and the seawrack found along the

coast can increase tenfold the worldwide production of alginates. Large-scale exploitation is, however, conditional upon the discovery of new areas of application for these products.

Despite the extensive natural resources, the researchers believe that it may be far more profitable to cultivate the algae instead of harvesting existing resources. This would make for a better control of raw materials supply and be an absolute condition for systematic processing of the plants.

## *Taiwan Fishes for Tuna Out of Uruguayan Port*

The Taiwanese Company, China Marine Trading (CMT), manages a fleet of longliners out of the port of Montevideo, Uruguay. CMT deploys its vessels for tuna in the South Atlantic, outside Uruguay's 200-mile zone[1], though the Taiwanese have reduced their fleet in Montevideo in recent years. As many as 240 longliners were once based in Montevideo.

During 1979 and 1980 the number of CMT vessels varied from 40 to 100. CMT claimed in mid-1979 that they would have to terminate their operations in Montevideo, primarily because of increased diesel fuel prices. Uruguay reportedly increased fuel prices 240 percent between January and July 1979[2]. CMT held talks with Venezuelan and Trinidadian officials during 1979, as low cost fuel is available in those two countries. No information is available, however, on the results of the talks.

CMT continued to operate vessels from Montevideo in 1980, however. It is believed that some arrangement was reached with Uruguayan officials to provide diesel fuel at prices near the international level, which is substantially less than Uruguayan domestic prices. Uruguayan officials would reportedly like to keep the Taiwanese fleet in Montevideo as CMT purchases between $5 and 7 million worth of goods and services annually.

The Taiwanese fishermen use Montevideo as a fishing base to obtain fuel and supplies, to store the catch, to exchange crews, etc. Business arrangements for CMT are taken care of by an Uruguayan company, Agentes Maritimos. CMT stations its longliners permanently in Montevideo. Crew members sign contracts for 2-year periods. The approximately 600 Taiwanese fishermen currently engaged in the fishery usually participate in 6 voyages of about 90 days during each 2-year contract period. Each vessel carries a crew of about 16 fishermen. The fishermen use longlines of about 60 km to which about 2,000 hooks are set by hand. The catch is maintained at about −35°C in the holds of the vessels.

The catch consists primarily of tuna, mostly albacore, but other tuna species such as bigeye, yellowfin, and bluefin are also taken. There is also a small incidental catch of shark, kingfish, black marlin, and various other species. The vessels usually do not return to port without a catch of at least 200 metric tons (t).

Data on the catch of the Taiwanese longline fleet[3] based in Montevideo is not available. The catch is stored in private and state-owned cold stores in bond and is exported primarily to the United States. These shipments have been subject to significant annual variations. The record year was 1978 when almost 2,700 t valued at $4.4 million was shipped to the United States (Table 1). (Source: IFR-81/34.)

**Table 1.—Albacore caught by Taiwanese and Korean (ROK) longliners and exported to the United States from Uruguay, 1971-October 1980.**

| Year | Quantity (t) | Value ($US1,000) |
|---|---|---|
| 1971 | — | — |
| 1972 | 62.5 | 66.5 |
| 1973 | 992.4 | 437.6 |
| 1974 | 585.2 | 258.0 |
| 1975 | — | — |
| 1976 | 1,585.7 | 699.2 |
| 1977 | 316.9 | 428.8 |
| 1978 | 2,654.2 | 4,434.0 |
| 1979 | 710.8 | 985.1 |
| 1980[1] | 1,240.7 | 2,904.0 |

[1]Through October.
Source: U.S. Department of Commerce, Bureau of the Census.

## Norway Reports 1980 Fish Catch and Value

In 1980 the total catch of fish landed in the Norwegian fisheries was a good 2.5 million t round-weight, the Norwegian Information Service reports. This is 235,000 t less than in 1979 and 190,000 t less than in 1978. The total catch of pelagic fish (capelin, herring, mackerel, blue whiting, Norway pout, sandeel, etc.) constituted a little over 1.7 million t, while the cod fisheries and others resulted in a catch of about 0.8 million t round weight. Compared with 1979 this was a drop of about 10 percent for the pelagic fish and of 5 percent for cod.

The first-hand value of the total catch amounted to about 3,300 million NOK. This is about 200 million NOK more than in 1979, and more than 400 million NOK more than in 1978. The yield for the pelagic fisheries in 1980 was 985 million NOK and for cod fisheries a good 2,300 million NOK. The increase in the value of the catch was divided between 41 million NOK for the pelagic fisheries and 159 million NOK for the cod fisheries.

## *Russia and Japan Sign Seaweed Pact*

A new agreement on the gathering of seaweed in Soviet territorial waters around Signalyy Island by Japanese fishermen was signed at the Soviet Ministry of Fisheries on 25 August 1981.

Complying with the wishes of Hokkaido fishermen, the Soviets agreed to give them permission to collect tangle in the waters around Signalyy Island. Under this agreement, 330 Japanese boats—the crew of each boat cannot exceed three—were allowed to gather tangle during daylight hours until 30 September 1981, beginning 25 August. The agreement also defined the area in which tangle gathering is permitted, waterways which Japan's fishing boats should use to enter the area, and other conditions. (Source: LSB 81-33.)

[1]Uruguay claims jurisdiction over tuna in its 200-mile zone and does not authorize the Taiwanese to fish within the 200-mile zone. There have been incidents, however, between the Uruguayan Navy and Taiwanese vessels attempting to fish within Uruguay's 200-mile zone. During August 1977, for example, the Uruguayan Navy seized the Taiwanese longliner *Chi nan-3*. The master failed to stop when ordered to do so, and the Uruguayan Navy fired on the vessel to disable it.

[2]Uruguay has to import almost all of its petroleum products and has set domestic fuel prices at high levels to discourage consumption.

[3]Unconfirmed reports suggest that Japanese and Korean (ROK) longliners are also based in Montevideo.

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"A Survey of Chlorinated Hydrocarbon Residues in Menhaden Fishery Products," Virginia F. Stout, Clifford R. Houle, and F. Lee Beezhold, 3:1-13.

"Acylation of Fish Protein: Effect of Reaction Conditions on Products," Kang-Ho Lee, Herman S. Groninger, and John Spinelli, 3:14-19.

"Radio Tracking Juvenile Marine Turtles," Robert E. Timko and David DeBlanc, 3:20-23.

### April

"Low Temperature Preservation of Seafoods: A Review," Louis J. Ronsivalli and Daniel W. Baker II, 4:1-15.

"Effect of Arterial Incisions on the Amount of Bleeding and Flesh Quality of Rainbow Trout," Wayne I. Tretsven and Benjamin G. Patten, 4:16-18.

"Movement of Tagged Sea Scallops on Georges Bank," J. A. Posgay, 4:19-25.

### May

"Sampling by U.S. Observers on Foreign Fishing Vessels in the Eastern Bering Sea and Aleutian Island Region, 1977-78," Russell Nelson, Jr., Robert French, and Janet Wall, 5:1-19.

"Foreign Fisheries in the Gulf of Alaska, 1977-78," Janet Wall, Robert French, and Russell Nelson, Jr., 5:20-35.

"The Foreign Fisheries off Washington, Oregon, and California, 1977-78," Robert French, Russell Nelson, Jr., and Janet Wall, 5:36-44.

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"Atlantic Skipjack Tuna: Influences of Mean Environmental Conditions on Their Vulnerability to Surface Fishing Gear," R. H. Evans, D. R. McLain, and R. A. Bauer, 6:1-11.

"Burnt Tuna: Conditions Leading to Rapid Deterioration in the Quality of Raw Tuna," J. L. Cramer, R. M. Nakamura, A. E. Dizon, and W. N. Ikehara, 6:12-16.

"Quality of Squid, *Illex illecebrosus*, Mantles Canned in Oil," Bohdan M. Slabyj, Gordon E. Ramsdell, and Ruth H. True, 6:17-20.

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"The Biology, Fisheries, and Management of the Queen Conch, *Strombus gigas*," Willard N. Brownell and John M. Stevely, 7:1-12.

"Habitat and Nursery Grounds of Pacific Rockfish, *Sebastes* spp., in Rocky Coastal Areas of Southeastern Alaska," H. Richard Carlson and Richard R. Straty, 7:13-19.

"Conditional Fishery Status as a Solution to Overcapitalization in the Gulf of Mexico Shrimp Fishery," Vito Blomo, 7:20-24.

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"A Biological and Economic Analysis of the North Carolina Charter Boat Fishery," Charles S. Manooch III, Leon E. Abbas, and Jeffrey L. Ross, 8:1-11.

"Paying-Passenger Recreational Fisheries of the Florida Gulf Coast and Keys," Joan A. Browder, J. Connor Davis, and Eulalie Sullivan, 8:12-20.

"Possible Temperature Effects on Charter Boat Catches of King Mackerel and Other Coastal Pelagic Species in Northwest Florida," William A. Fable, Jr., Harold A. Brusher, Lee Trent, and Joe Finnegan, Jr., 8:21-26.

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"Anchored Fish Aggregating Devices in Hawaiian Waters," Walter M. Matsumoto, Thomas K. Kazama, and Donald C. Aasted, 9:1-13.

"The Performance and Environmental Effects of a Hydraulic Clam Dredge," Thomas L. Meyer, Richard A. Cooper, and Kenneth J. Pecci, 9:14-22.

"A Comparison of Rearing Costs and Returns of Selected Herbivorous, Omnivorous, and Carnivorous, Aquatic Species," Yung C. Shang, 9:23-24.

### October

"Marine Resource Management Under Uncertainty: The Case of Eastern Spinner Dolphin Depletion," James K. Sebenius, 10:1-4.

"Spore Structure of *Minchinia chitonis*," S. J. Ball, 10:5-8.

"Histamine Formation and Honeycombing During Decomposition of Skipjack Tuna, *Katsuwonus pelamis*, at Elevated Temperatures," Hilmer A. Frank, Derrick H. Yoshinaga, and Wai-Kit Nip, 10:9-14.

"Physical Properties of Blue Shark Useful in Designing a Skinning Machine," D. E. Brown, R. Paul Singh, R. E. Garrett, and Barbara Katz, 10:15-22.

### November

"A Management Model of the Northwest African Cephalopod Fishery," W. E. Grant, W. L. Griffin, and J. P. Warren, 11:1-10.

"Demonstration of Advances in Virgin Islands Small Boat Fishing Techniques," David A. Olsen and Joseph A. LaPlace, 11:11-15.

"A Corral System for Examining Pelagic Dolphin Schools," J. G. Jennings, J. M. Coe, and Walter F. Gandy, 11:16-20.

### December

"Areal Distribution of Marked Columbia River Basin Spring Chinook Salmon Recovered in Fisheries and at Parent Hatcheries," Roy J. Wahle, Ed Chaney, and Roger E. Pearson, 12:1-9.

"Deepwater Shrimp Resources in Vanuatu: A Preliminary Survey off Port Vila," Michael G. King, 12:10-17.

"Frozen Storage Stability of Whole and Headless Freshwater Prawns, *Macrobrachium rosenbergii*," Malcolm B. Hale and Melvin E. Waters, 12:18-21.

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*Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

### The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

### Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

### Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

### Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

### Literature Citations

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

### Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10-inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

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First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

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